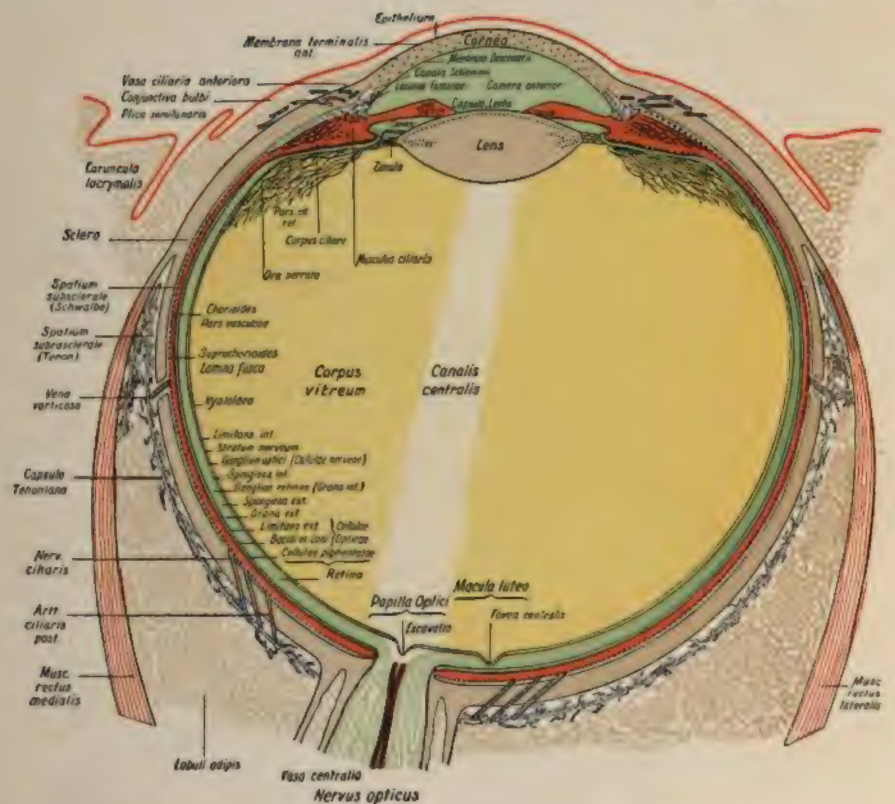
A PRACTICAL TREATISE ON

OPHTHALMOLOGY

PLATE I



LONGITUDINAL SECTION OF THE EYEBALL. (MAGNUS.)

A PRACTICAL TREATISE

ON

OPHTHALMOLOGY

BY

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WITH SIX COLORED PLATES AND THREE HUNDRED ILLUSTRATIONS IN TEXT

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THIS WORK

IS AFFECTIONATELY DEDICATED

TO MY FATHER

THOMAS G. FOX, M.D.

PREFACE

In preparing this work an effort has been made to present a comprehensive treatise on Ophthalmology, including references to the many researches and great advances which have been made in this department of medicine and surgery in recent years. In a work of such a character it is necessary to include chapters on the anatomy of the eye and the physiology of vision for the purpose of assisting the student to refresh his memory on subjects which may have become somewhat clouded by the study of other important branches during the last years of his college course.

The bacteriology of the eye has received especial attention, the various microörganisms being carefully classified and considered in connection with affections of the conjunctiva, cornea, and the uveal tract. The relation of general diseases to diseases of the eye has also been carefully pointed out. The operations which have proved to be the most beneficial have been selected for description as standards. The most modern theories in reference to color perception and color blindness have been presented and full particulars have been given of the latest therapeutic measures which have yielded reliable results in combating ophthalmic diseases.

Those chapters which treat of ocular muscle imbalance and the errors of refraction are sufficiently comprehensive to give working basis for the general practitioner and the student who wish to perfect themselves in this department of ophthalmology.

The author is indebted to Dr. Frank S. Bowman, Demonstrator of Anatomy in the Medico-Chirurgical College, for Plate II, and for his revision of the chapters on the anatomy of the

eye; to Dr. D. Rivas, Bacteriologist to the Department of Health for the State of Pennsylvania, for his valuable aid in the study of the bacteriology of the conjunctiva, cornea, and uveal tract, and to Dr. H. C. Goldberg for his work on laboratory technic as found in Chapter XXV. The author also wishes to acknowledge his indebtedness to Professor Edwin J. Houston, Dr. Warren C. Batroff, and Dr. Robert C. Moon for valuable assistance rendered during the progress of this work.

L. Webster Fox.

1304 Walnut Street,
Philadelphia.

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A PRACTICAL TREATISE ON OPHTHALMOLOGY

CHAPTER I

DEVELOPMENT OF THE EYE

For the sake of simplicity, the eye, one of the organs of special sense, may be divided into three parts:

1. The receiving portion—the eye proper—consisting of a sensory layer (the retina) situated at the focusing point of a compound system of lenses, the power of which is regulated by the action of the muscle of accommodation.

2. The transmitting portion, which is composed of nerve material.

3. The percipient portion, that area of the cerebral cortex which is made up of the distributed central portions of the nerve material.

The *optic vesicle,* which is the first indication in the development of the visual apparatus, makes its appearance in the human embryo about the fifteenth day as a large diverticulum extending on each side of the primary forebrain vesicle, and subsequently becoming connected with the interbrain or thalamencephalon. The optic vesicle continues to develop, until at about the twentieth day it lies directly under, and in contact with, the ectoderm. As the development progresses, the ectoderm opposite the external pole of the vesicle thickens; this area of ectodermic thickening is the first indication of the crystalline lens, the development of which proceeds as follows:

The thickened ectoderm at this point becomes depressed, forming an inverted pouch which is directed toward the optic vesicle, the anterior wall of which it invaginates. This invagination progresses until a closed sac, the *lens vesicle,* is formed, which eventually separates from the ectoderm. The lens is accordingly an epithelial structure, being derived from the external germinal layer or ectoderm. In the first stages of its development it con-

sists of a hollow vesicle, which later becomes filled by the growth of its cells and is converted into a solid spherical mass.

Simultaneously with the formation of the lens the anterior segment of the optic vesicle is forced in by the growing ectoderm until the cavity is largely obliterated, and a new vesicle is formed between the primitive lens and the anterior wall of the primary optic vesicle. This new vesicle, which is known as the ocular cup, or secondary optic vesicle, subsequently becomes the vitreous chamber.

When the invagination of the secondary optic vesicle by the rudimentary lens takes place, the lens fills the cavity of the vesicle completely, no vitreous as yet existing. The vitreous, in its ear-

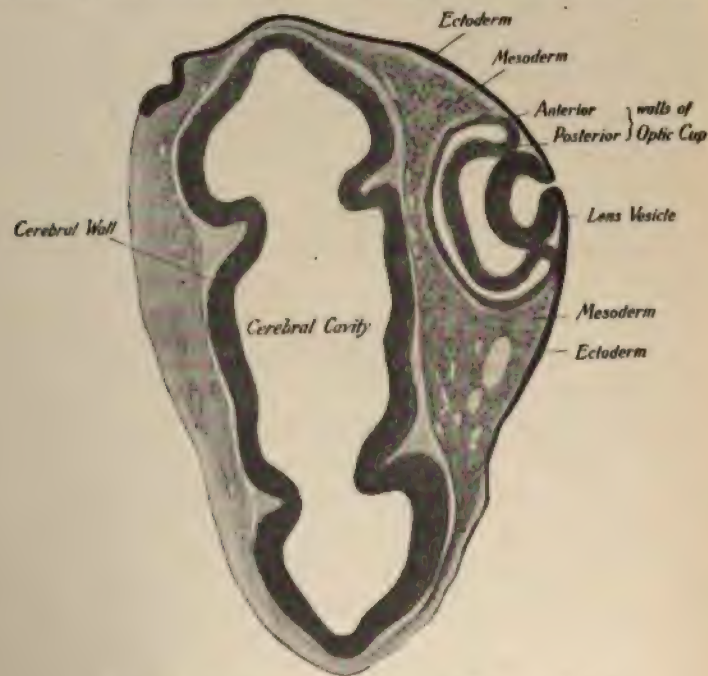


FIG. 1.—EMBRYONIC EYE OF A CHICK. (Fick.)

liest stages, is essentially connective tissue derived from the middle germinal layer, or mesoderm, which surrounds the optic vesicle.

The optic vesicle not only undergoes invagination at its anterior pole, but also along its inferior border, as well as along

the optic stalk. As a consequence of this process, the vesicle is not completely closed. This cleft, or defect, known as the choroidal fissure, is continued backward upon the pedicle of the optic vesicle (the optic nerve) in the form of a groove or furrow. The mesoderm, pushing its way through the choroidal fissure,

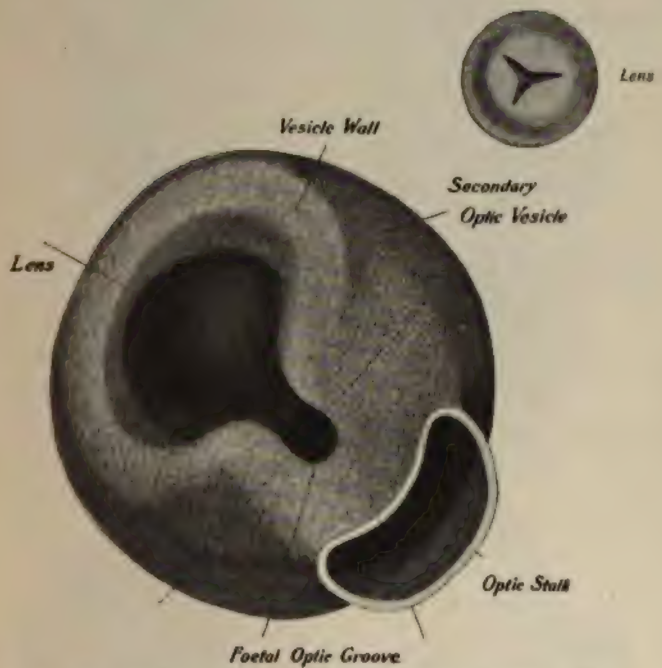


FIG. 2.—DEVELOPMENT OF THE CRYSTALLINE LENS. (Fick.)

grows into the interior of the eye between the lens and retina, and becomes converted into the vitreous. In the course of normal development, the margins of the choroidal fissure are united before birth, so that a closed vesicle is again formed. In some rare instances, however, the fissure is imperfectly closed, resulting in a defective inferior border of the iris, choroid, or optic nerve (coloboma).

By the union of the edges of this fissure, the vitreous is isolated from the surrounding mesoderm, which goes to form the uveal tract, the sclera, and the cornea.

The edges of the cleft in the optic nerve, corresponding to the choroidal fissure, also unite, inclosing a certain portion of meso-

dermic tissue. This develops, after the third month, into the central vessels of the optic nerve, which are continued forward into the vitreous.

The retina is also developed from the primary optic vesicle, the posterior or outer layer becoming reduced in thickness, and its cells assuming a cuboidal shape with pigmented granules. This is the rudimentary pigment layer of the retina. The invaginated

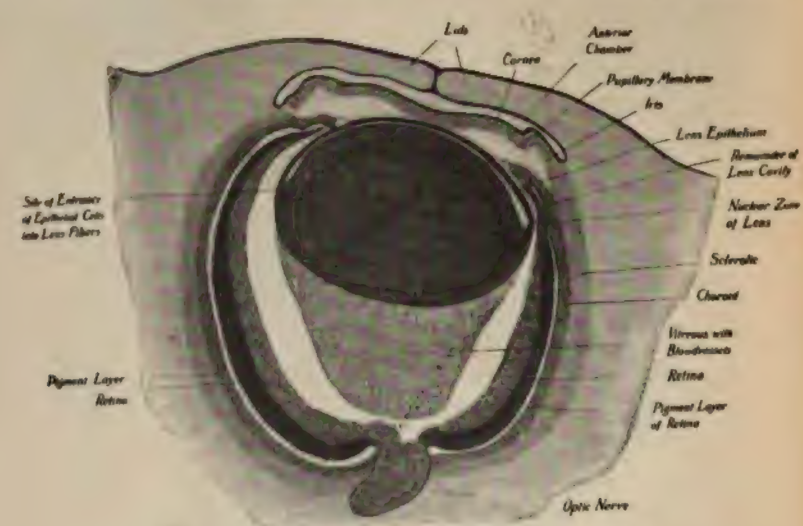


FIG. 3.—DEVELOPMENT OF THE EYE. (Fick.)

anterior or inner layer, however, becomes thicker, owing to an increase in the number of its cells, which are of the spindle-shaped variety. This layer differentiates into two kinds of cells, one comprising the sustentacular elements (Müller's fibers), and the other the nerve cells.

From the sustentacular cells, Müller's fibers and their branches, together with the inner and outer limiting membranes, various nervous elements, such as the bipolar cells, the layer of ganglion cells, etc., take their origin.

The rods and cones, which are incompletely developed at birth, grow from the outer extremities of the rod- and cone-visual cells and project through the external limiting membrane. The macula lutea also remains undeveloped until after birth.

The retinal nerve fibers are the last to develop, and their deri-

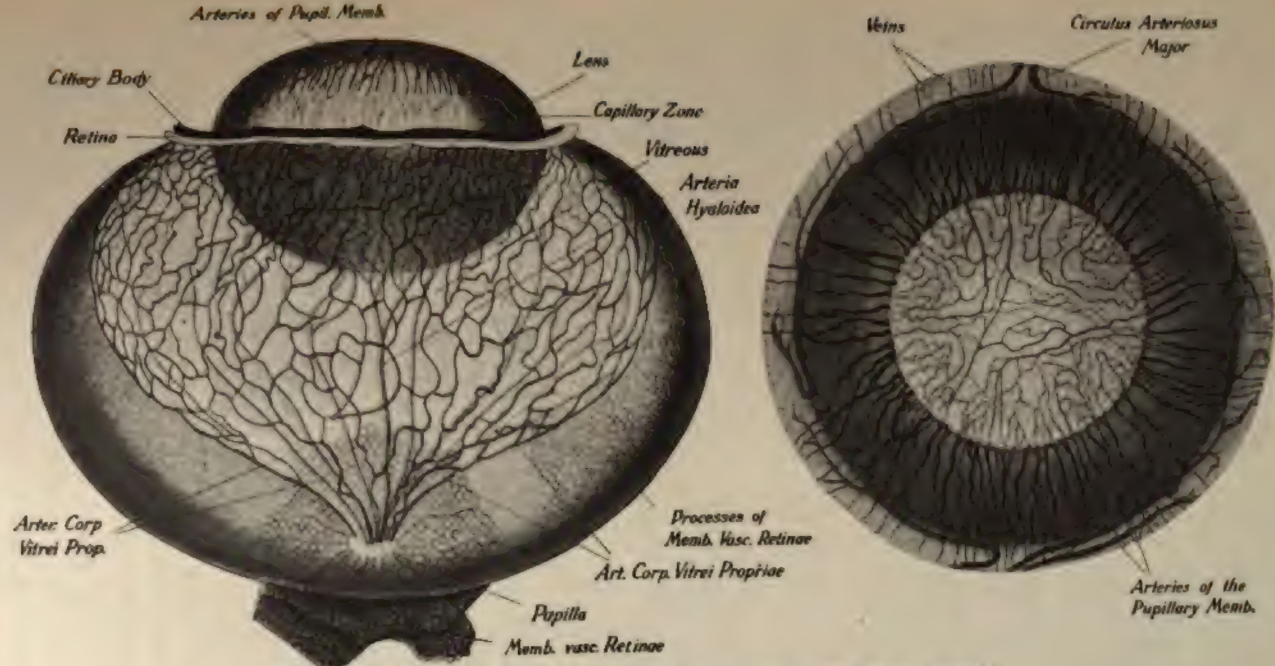


FIG. 4.—THE EMBRYONIC VASCULAR SYSTEM OF THE EYE. (Fick.)

vation has not been indisputably determined. It is assumed however, that they are developed from the neuroblasts of the retina itself, and from those of the interbrain. (They are the axones of the cells of the ganglion-cell layer of the retina.—Müller.)

On close examination the vessels of the eye, in its embryonic stage of development, will be seen to be arranged as follows:

The central portion of the vitreous is occupied by a small canal through which the arteria centralis, as the hyaloid artery, continues its course to the posterior wall of the lens. Small lateral branches of this artery, forming an arterial network, are given off in the periphery of the vitreous and margin of the lens. The blood-vessels of the vitreous disappear several months before birth, the hyaloid artery being replaced by a canal (canal of Stilling, or canal of Cloquet) which persists in adult life.

The crystalline lens is derived from the ectodermic vesicle, previously described, the walls of which vary greatly in thickness. The anterior lamina is retained as a part of the anterior lens-capsule and is comparatively thin. The posterior lamina is provided with cells, the elongation and subsequent transformation of which furnish the lens fibers and greater portion of the lens substance. The anterior and posterior capsules of the lens are derived from the mesoderm and are therefore genetically distinct from the lens.

The fetal lens is surrounded by a vascular membrane, derived from the mesoderm, known as the *tunica vasculosa lentis*, which in the region of the pupil is called the *pupillary membrane* (*membrana pupillaris*) and the remaining portion of which is designated the *capsular membrane* (*membrana capsularis*). This vascular membrane, from which the developing lens derives its nutrition, disappears two months preceding birth. Small portions of this tunic in the pupillary area are, however, quite frequently seen in the newly born as a thin membrane closing the pupil, causing a congenital defect of the eye known as *atresia pupillæ congenita*.

As already stated, the cornea, sclera, and uveal tract are derived from the mesoderm surrounding the fetal optic vesicle. This mesoderm may be considered as consisting of an outer and inner layer of cells, the cornea and sclera being a product of the former, and the uvea of the latter.

The choroid is mesodermic in origin, appearing first as a fibrous tunic. The vascular networks are not produced until comparatively late.

The iris and ciliary body, the most anterior portions of the uvea, arise from that layer of mesoderm which covers the anterior wall of the vesicle, and which also furnishes the inner lining for both these structures.

The eyelids are formed at the end of the third month as folds of ectoderm containing mesodermic tissue; this mesodermic tissue grows out above and below the skin surrounding the eye until the free margins come into immediate contact and fuse in front of the globe. Separation of the eyelids takes place shortly before birth.

The conjunctiva develops from the ectoderm which covers the surface of the embryo.

The lacrymal gland takes its origin from small epithelial islands of the primitive conjunctiva, growing into the orbital tissue.

The lacrymal canal arises as a thickening of the ectodermic cells at the bottom of the groove, which extends upward toward the eye between the fronto-nasal and superior maxillary processes. A hollowing out of this thickening takes place, the edges or lips meeting over the groove, resulting in complete isolation of the canal from the surface.

To summarize, the three essential organs of the eye—the optic nerve, the retina, with its two layers, the retina proper, and the pigmented layer, and the lens—are the first parts of the eye to develop. The remaining structures, the sclera, the vitreous, the aqueous humor, the iris, the muscles of accommodation, etc., either grow into or around the ball or optic cup, secondarily.

CHAPTER II

ANATOMY OF THE EYE

THE human eyeball is nearly spherical in form. It is situated in the orbital cavity, in the anterior part of the skull, and is protected anteriorly by the eyebrow, eyelashes, and eyelids, and posteriorly by adipose tissue. It is acted upon by muscles, and is supplied by blood-vessels and nerves.

The Orbit.—The orbits are four-sided pyramidal bony cavities, with their bases pointing anteriorly and apices posteriorly. Each orbital cavity is formed by seven bones, viz.:

Superior maxillary.
Malar.
Palate.
Frontal.
Sphenoid.
Ethmoid.
Lacrymal.

Of these, the frontal, sphenoid, and ethmoid are common to both orbits. For convenience of study, the bones entering into the formation of the orbital cavity may be arranged in the following manner:

1. *Floor.*
   Orbital plate of superior maxillary bone; portion of the malar bone; orbital process of palate bone.
2. *Roof.*
   Orbital plate of frontal bone, mainly; at apex, the lesser wing of sphenoid bone.
3. *Inner Wall.*
   Os planum of ethmoid bone; orbital surface of lacrymal bone; orbital portion of sphenoid bone posteriorly; nasal process of superior maxillary bone anteriorly.

FIG. 5.—SKULL AND ORBITS. (Cryer.)

1, Os planum of ethmoid; 2, lacrymal; 3, nasal process of superior maxillary; 4, frontal bone (supra-orbital ridge); 5, malar (part of infra-orbital ridge); 6, orbital process of superior maxillary; 7, superior maxillary (part of infra-orbital ridge); 8, orbital process of sphenoid; 9, lesser wing of sphenoid and optic foramen; 10, sphenoidal fissure or anterior lacerated foramen, 11, spheno-maxillary fissure; 12, infra-orbital groove; 13, infra-orbital foramen; 14, supra-orbital foramen; 15, anterior ethmoidal foramen; 16, posterior ethmoidal foramen; 17, nasal bone; 18, malar foramen; 19, lacrymal canal.

4. *Outer Wall.*

Posteriorly, anterior surface of greater wings of sphenoid bone; anteriorly, orbital process of malar bone.

The thinnest portions of the orbit are the roof and nasal wall; the floor is somewhat thicker, and the outer wall is from five to six times as thick as the inner wall. Each orbital cavity has nine openings—five foramina, two canals, and two fissures. These openings are as follows:

1. *Optic Foramen.*

The communication from the apex of the orbital cavity with the cranial cavity transmitting the optic nerve, the ophthalmic artery, and a process of the dura mater. To the inner and lower portions of the circumference of this foramen the ligament of Zinn is attached.

2. *Anterior Ethmoidal Foramen.*

At the junction of the inner wall and the roof, transmits the anterior ethmoidal vessels and the nasal nerve.

3. *Posterior Ethmoidal Foramen.*

About one third of an inch posterior to the preceding; transmits the posterior ethmoidal vessels.

4. *Malar Foramina.*

Found in that part of the outer wall formed by the malar bone. They open into the temporal fossa and upon the external surface of the malar bone. They transmit the temporal and malar branches of the orbital nerve and the malar branches of the lacrymal artery.

5. *Supra-orbital Foramen* (usually a notch).

At the junction of the inner and middle thirds of the upper circumference; it transmits the supra-orbital artery, vein, and nerve.

6. *Sphenoidal Fissure* (Anterior Lacerated Foramen).

At the back part of the cavity communicating with the cranial cavity. It transmits the third, fourth, three branches of the ophthalmic division of the fifth, and the sixth cranial nerves; filaments from the cavernous plexus of the sympathetic nerve; the ophthalmic vein; and a process of the dura mater.

7. *Spheno-maxillary Fissure.*

Found separating the floor from the outer wall in the posterior half of the cavity. It communicates with the spheno-maxillary and the zygomatic fossæ, and transmits the infra-orbital vessels; the superior maxillary division of the fifth nerve and its orbital branches; and the ascending branches of the spheno-palatine or Meckel's ganglion.

8. *Infra-orbital Canal.*

Situated about the middle of the posterior portion of the floor. It receives the terminal portions of the internal maxillary artery and the superior maxillary nerve, which are here known as the infra-orbital vessels and nerve.

9. *Lacrymal Canal.*

A canal found at the anterior part of the junction of the floor and the inner wall establishing a communication with the inferior meatus of the nasal fossæ. In its upper part is lodged the lacrymal sac; its lower part is principally concerned in transmitting the nasal duct, through which the tears pass to the nose.

Within the orbit the eye rests upon a bed of fat, from which it is separated by a membranous sac—the capsule of Tenon.

For convenience in describing the eye, the following terms are in common use:

a. Dimensions of the Eyeball.

	Antero-posterior	Transverse	Vertical
Piersol	24.2 mm.	23.6 mm.	23.2 mm.
Morris & Deaver	24.5 mm.	23.9 mm.	23.5 mm.
Quain	24.0 mm.	24.5 mm.	23.5 mm.
Cunningham ...	Anterior-posterior and transverse about equal, about 24 mm.; vertical, about 23.5 mm.		
Gray..........	The eyeball measures rather more in its transverse and antero-posterior diameters than in its vertical diameter, the former amounting to nearly an inch, and the latter to about nine tenths of an inch.		

b. The anterior and posterior poles are the geometric centers of the cornea and fundus, respectively.

c. The optic axis is a straight line passing through the anterior and posterior poles of the eye.

d. The nodal point is an imaginary point—the center of curvature of the refracting media—where all the luminous rays pass without deviation.

e. The line of vision or visual axis is an imaginary line passing through the nodal point, which connects the point of fixation with the fovea centralis. It usually lies to the outer side of the center of the pupil. As it passes through the cornea it forms with the optic axis the visual angle—an angle of from 3 to 7 degrees.

f. The equatorial plane is an imaginary plane passing through the center of the eyeball at right angles to the optic axis, dividing the globe into anterior and posterior hemispheres.

g. The equator is the line passing around the globe through the points cut by the equatorial plane.

h. Meridional planes are imaginary antero-posterior planes which are at right angles to the equatorial plane, both in their vertical and horizontal direction.

i. Meridians are lines passing through points upon the surface of the globe, where it is cut by the meridional planes.

Capsule of Tenon (*Tunica vaginalis oculi*).—The capsule of Tenon is a fascia between that part of the eyeball posterior to the attachments of the muscles and the fatty tissue of the orbit, isolating the eyeball and allowing free movement.

It consists of two layers—an internal or visceral and an external or parietal.

a. The Internal or Visceral Layer.—The eyeball rests in this part of the capsule much as an acorn lies in its cup. Traced from the entrance of the optic nerve within the orbital cavity, it passes forward, forming an outward sheath for the nerve; reaching the eyeball, it forms a socket in which lies the greater part of the globe of the eye, extending forward nearly to the insertion of the muscles, where it becomes reflected to form the external or parietal layer. The scleral surface of this layer is lined with endothelial cells, thus receiving the character of a serous membrane. A space intervenes between it and the sclera known as the suprascleral lymph space or the space of Tenon. It is closely attached to the

sclera around the entrance of the optic nerve. Still farther radially it is pierced by the ciliary vessels and nerves, and near the equator by the venæ vorticosæ.

b. The External or Parietal Layer.—This layer is by some described as a part of the orbital fascia. It passes from the reflection of the internal layer backward, lining the cushion of fat, to the optic foramen. At the anterior part of the capsule the tendons of the rectus muscles are said to pierce the membrane, from which point they are invested by a strong tubular sheath to their insertion. This part of the capsule is strengthened and passing laterally from one tendon to another, giving the appearance of a broadened, circularly arranged, aponeurosis of insertion of the muscles. From this circle fibers pass to be attached to the sclera near its junction with the cornea; others become attached to the conjunctiva, and continuing to the margin of the circumference of the orbit, where they blend with the periosteum.

At intervals this radiation to the orbital margin is thickened. More particularly is this noticed where it passes from the tendons of the internal and external rectus muscles, and here receives the name of check ligaments.

From the superior and inferior muscles these thickenings, less marked, can be traced into the connective tissues of the eyelids.

Inferiorly is a thickening of the capsule known as the suspensory ligament of Haywood. It supports the eye somewhat as a hammocklike sling. It is attached externally to the malar bone, and passing under the eye is attached internally to the crest of the lacrymal bone.

Eyeball.—The eyeball is composed of segments of two spheres of different size. The larger segment (*sclerotic*), which is opaque, forms about $\frac{5}{6}$ of the globe, and is designed for the protection of its contents; the smaller segment (*cornea*) is transparent and is implanted upon the larger, with which it is continuous in front. The optic nerves enter the eyeballs a little to their nasal side, in the direction of the axes of the orbit, which are not parallel with the axes of the eyeball, but are directed outward.

The eyeball is composed of three tunics or coats:

1. Sclerotic and cornea.
2. Choroid, ciliary body, and iris.
3. Retina.

There are also three humors, which, together wit[illegible] nea, form the refracting media of the eye. These are:

1. Aqueous humor.
2. Crystalline lens (and capsule).
3. Vitreous humor, or body.

There are likewise three chambers—namely:

1. Anterior chamber.
2. Posterior chamber.
3. Vitreous chamber.

Sclerotic Coat.—The sclerotic coat, so called from i[illegible] density, is thicker behind (1 mm.) than in front (0.4 [illegible] presents for study two surfaces—the external and inter[illegible] external surface is smooth and white, and to it are att[illegible] various extrinsic muscles of the eye.

The internal surface is grooved for the passage of t[illegible] nerves, and is connected to the choroid by a fine cellula[illegible] layer—the lamina fusca. Posteriorly, and a little to [illegible] side, the sclerotic is pierced by the optic nerve. Where t[illegible] lemma of the fibers ceases, as the nerve penetrates this [illegible] nerve is constricted by the lamina cribrosa, a sievelike cont[illegible] of the sclerotic coat. One of the openings in the lamina [illegible] larger than the rest, known as the *porus opticus*, transr[illegible] arteria centralis retinæ.

Some distance from the entrance of the optic nerve th[illegible] is perforated for the entrance of the ciliary vessels and [illegible] and at the equator are found the four or five larger op[illegible] equally distant from each other, transmitting the *venæ vor*[illegible]

The sclera is continuous in front with the cornea, overla[illegible] it a little on its outer margin. In structure it is compos[illegible] strong, white, fibrous tissue, with a small quantity of elastic [illegible] and connective-tissue corpuscles. It contains very few, if [illegible] nerves.

Cornea. The cornea is the convex, transparent, nearly [illegible] cular tissue forming the anterior $\frac{1}{6}$ of the globe. In mature i[illegible] viduals it is from 0.8 to 1.2 mm. in thickness. Its thicknes[illegible] the periphery is 1.12 mm., the curvature of the posterior s[illegible] face more nearly approximating to that of a true sphere than t[illegible] anterior. It is a trifle greater in its transverse than its vertica[illegible] diameter, and, owing to the overlapping of the sclera above and

Choroid.—The second tunic, or uveal tract, consist parts—choroid, ciliary body, and iris.

The choroid is a dark, reddish-brown, highly vascul membrane, lining the sclerotic coat from the optic ne ciliary body. Its outer in contact with the inne the sclerotic, to which tached by the membra and on its inner surface is supported.

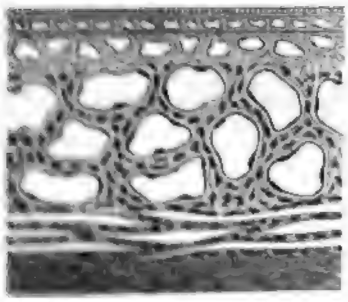


Fig. 6. Choroid. (Magnus.)
1, Retinal pigment epithelium; 2, lamina vitrea; 3, membrana Ruyschii; 4, Sattler's layer, or chorio-capillaris; 5, tunica vasculosa Halleri; 6, membrana fusca.

The structure of th consists chiefly of a dens network.

There are three lay choroid. Named from w ward, they are the lami choroidea, the choroid pr the lamina basilis.

The *lamina suprachoroidea*, the most external layer, the lamina fusca. It is composed of delicate nonvascula each consisting of fine elastic fibers with a few branche cells. The spaces between the lamellæ are lined with en and communicate with the perichoroidal lymph space.

The *choroid proper* contains the vessels of this tunic cause of their arrangement this part is found in two lay *lamina vasculosa*, or outer layer, consists in part of t branches of the short posterior ciliary arteries which run the veins before they bend inward to terminate in the c but this layer is formed principally by veins, which venæ vorticosæ because of their whirl-like arrangemen converge at four or five equidistant points and emerg the sclerotic midway between the optic nerve and the the cornea. Interspersed between the vessels are la shaped, pigment cells, the processes of which commun each other to form a delicate network or stroma.

The *lamina choriocapillaris, tunic of Ruysch, or t* *vasculosa*, the internal layer, is composed of a close netw capillaries derived from the short ciliary arteries, and ous in front with the vessels of the ciliary processes.

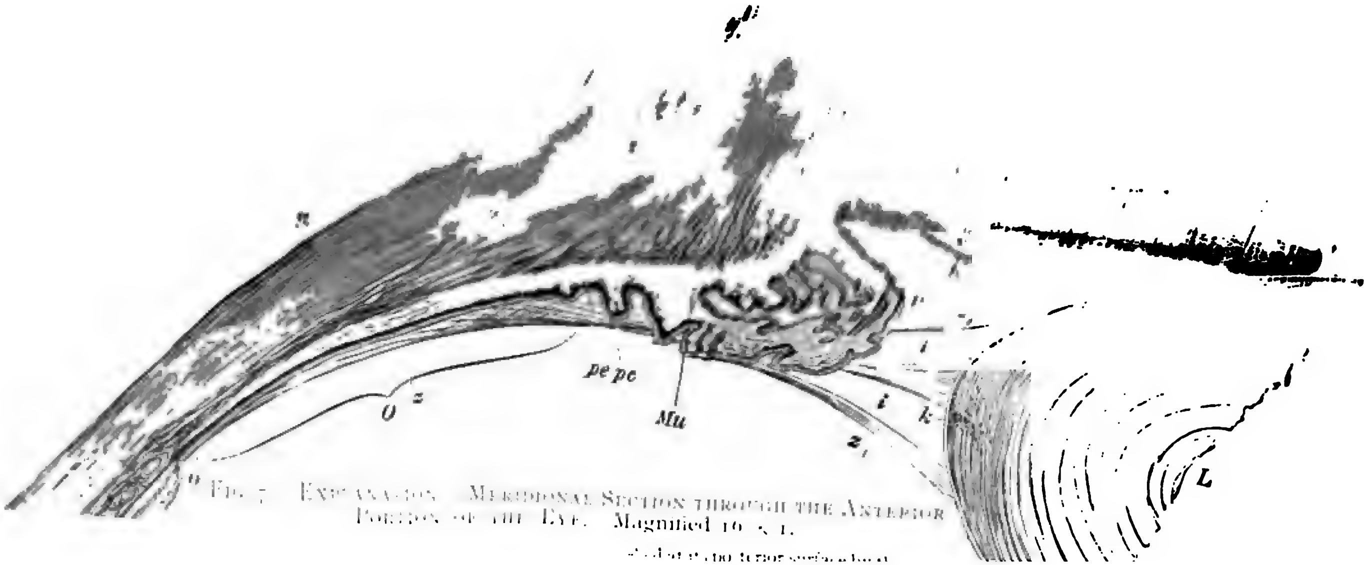


Fig. 7. Explanation: Meridional Section through the Anterior Portion of the Eye. Magnified 10 × 1.

Retina.— The retina is a delicate, white membrane, rich in nerve structure, the expansion of the optic nerve. Externally it is in contact with the choroid, and internally with the vitreous body. In front near the ciliary processes the nerve elements of the retina suddenly end in a jagged margin called the *ora serrata.* In front of the ora serrata the retina is prolonged over the ciliary processes in the form of two layers of cells—an inner layer of columnar epithelium and an outer consisting of pigmented cells. The two in this region are known as the pars ciliaris retinæ. These layers continue to the back of the iris, where they are more pigmented and are known as the pars iridica retinæ.

Its internal surface, at a point corresponding to the axis of the eyeball, presents a small, round spot of yellowish color, the *macula lutea*, or yellow spot of Sömmering. In the center of the macula lutea is a central depression, the *fovea centralis*, the region of most acute vision. Near a point corresponding to the axis of the orbit and about 3 mm. to its nasal side the optic

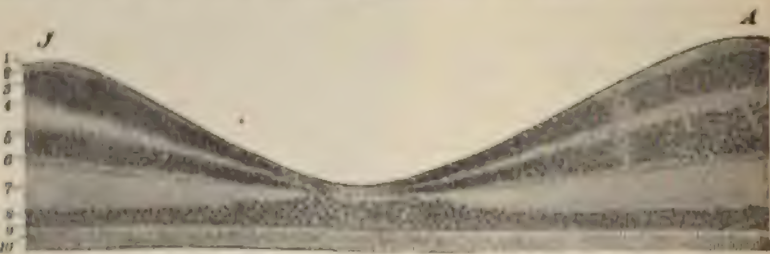


FIG. 8.—THE RETINA AND MACULA LUTEA. (Greeff.)

1, Membrana limitans interna; 2, nerve fiber layer; 3, ganglion cell layer; 4, inner molecular layer; 5, inner nuclear layer; 6, outer molecular layer; 7, outer nuclear layer; 8, membrana limitans externa; 9, layer of rods and cones; 10, pigment epithelial layer.

nerve makes its entrance through the *porus opticus*, an oval, bluish-white depression, with distinct, often pigmented margins. This region, which is destitute of vision, is the optic disk—often called the *blind spot*. The center of the nerve is pierced by the *arteria centralis retinæ*, which gives off branches to the nasal, upper, and lower sides of the macular region.

The structure of the retina is exceedingly complex, and when examined microscopically is seen to be made up of ten layers from within outward, as follows:

1. The *membrana limitans interna*, which is in contact with

the hyaloid membrane of the vitreous humor, is the most internal layer of the retina. It is formed by the expanded bases of Müller's fibers, from which fibers the *membrana limitans externa* is also derived.

2. The *fibrous layer*, made up of nerve fibers—the terminal optic nerve fibers.

3. The *vesicular layer*, or *ganglion-cell layer*, composed of a single layer of large, flask-shaped ganglionic cells. In the macular region these cells become more numerous, until at the margin of the fovea they are six or eight deep. Their axones are the fibers of the optic nerve.

4. The *inner molecular layer* is composed of a layer of granularlike structure forming a reticulum composed of networks of neuroglia and the branched processes of various nerve cells of adjacent layers. This layer incloses minute granules of unknown nature.

5. The *inner nuclear layer* is composed of three sets of nuclear bodies, the first resembling bipolar nerve cells, the second a stratum of cells without branches, and the third continuous with the radiating fibers or fibers of Müller.

6. The *outer molecular layer* is much thinner than, but closely resembles, the inner molecular layer, from which it differs, however, in the fact that it contains branched stellate cells.

7. The *outer nuclear layer* is composed of several layers of nuclear cells, separable into two kinds: the *rod granules* and the *cone granules*, both continuous with the rods and cones of Jacob's membrane, being the nuclei and the modified bodies of the specialized epithelial cells, of which the rods and cones are the processes.

8. The *membrana limitans externa*, like the internal limiting membrane, is derived from the radiating fibers or fibers of Müller.

9. *Jacob's membrane*, or the layer of rods and cones, consists of two distinct kinds of elements, the rods and cones, which are distributed alternately throughout this layer, the rods being much more numerous.

The rods are solid, stand perpendicularly to the surface, and consist of two portions: the outer portion striated, and the inner granular.

The cones are flask-shaped, with their pointed extremities toward the choroid. They also consist of two portions: the outer portion striated, and the inner granular.

The layer of rods and cones, together with the rod and cone "granules" of the outer nuclear layer, constitute one continuous layer of neuro-epithelium.

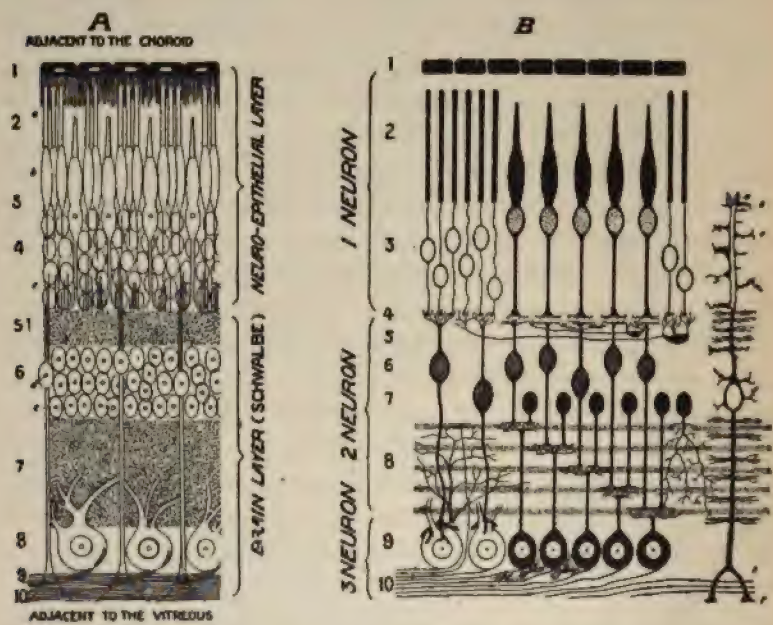


FIG. 9.—STRUCTURE OF THE HUMAN RETINA. (Diagrammatic.)

10. The *pigmentary layer*, which was formerly described as a layer of the choroid, has received the name *tapetum nigrum*. It consists of a single layer of hexagonal, epithelial cells loaded with pigment granules. In many mammals the pigment particles are absent, but their reflex is substituted by the *tapetum lucidum*, an iridescent luster supplied by the choroid.

The radiating fibers, or fibers of Müller, are derived from a part of the original epithelial cells of the optic cup. They serve to connect the various layers of the retina constituting their stroma, and, as has been already mentioned, form the external and internal limiting membranes.

The structure of the retina undergoes important alterations to

form the macula lutea. One of the most striking changes, perhaps, is the diffuse yellow pigmentation, limited to this area, which serves in the recognition of this region in examination with the ophthalmoscope.

Histologically, there is no continuity of the nerve-fiber layer; Jacob's membrane is represented by the cones alone; the ganglion cells of the vesicular layer undergo extraordinary development and form several layers of cells, and the outer nuclear layer consists only of cone fibers that have become elongated and curved.

The fovea centralis results from the hollowing out of the macula in consequence of the thinning and later disappearance of some of the retinal layers. The cones of Jacob's membrane, the external nuclear layer, and the internal granular layer constitute the remaining portions of the retina in this situation. Within a central area of 5 mm. width there is an entire absence of blood-vessels. The fovea centralis is devoid of pigment.

The arteria centralis retinæ supplies the retina only as far as the inner nuclear layer.

Aqueous Humor.—The aqueous humor is a transparent, alkaline, serous substance or fluid, small in quantity—weighing 4 to 5 grains—which fills the anterior and posterior chambers of the eye. It is composed of water, 98.6 per cent, small quantities of solids; extractive matters, principally chlorid of sodium, and proteids.

The *anterior chamber* is the space (about 2.7 mm. in depth) between the iris and cornea.

The *posterior chamber* is the space formerly described as existing between the anterior surface of the lens and the iris. It amounts to a space only between the peripheral part of the iris, the suspensory ligament, and the ciliary process, the lens and iris being in contact at the posterior surface.

Communication between these chambers is free in the adult through the pupil, but in the fetus the pupillary membrane serves to separate them until its disappearance at the seventh month of intra-uterine life.

Crystalline Lens.—The crystalline lens is a biconvex, transparent, elastic body inclosed in a capsule—which is connected laterally with the suspensory ligament—and surrounded by the ciliary processes. It is more convex on its posterior surface, the

anterior surface having a radius of approximately 10 mm. when accommodating for far vision and 6 mm. for near, while the radius of the posterior surface under similar conditions is 6 mm. and 5 mm. respectively. The posterior surface of the lens rests in the hyaloid fossa of the vitreous.

The lens measures about 8 to 10 mm. in transverse diameter, about 4 mm. in antero-posterior diameter, and weighs from 0.2 to 0.25 gm.

Its index of refraction increases from the periphery to the center, the average being 1.4371 (Helmholtz).

It is composed of about 60 per cent water; soluble albuminous matter 35 per cent; insoluble albuminous matter 2.5 per cent; cholesterin and fat 2 per cent.

The structure of the lens consists of concentric laminæ, made up of hexagonal prisms, about 0.005 mm. in breadth, united laterally by dentated margins and curving round the borders of the lens. The laminæ are arranged into three triangular segments.

The central portion, or nucleus, is unstriated, while the fibers of the outer layer each contain a nucleus and form the cortex.

The *capsule of the lens* is a transparent, elastic, brittle membrane inclosing the lens, and held in position by the suspensory ligament. Its anterior layer is thicker than the posterior, and is attached to the lens by a layer of polygonal, nucleated cells, which break down after death to form the *liquor Morgagni*. Epithelial cells are absent on the posterior surface.

The *canal of Petit* is about 2.5 mm. in diameter, traversing the circumference of the lens capsule. Its base is formed by the capsule, and it is bounded in front by the suspensory ligament, and behind by the hyaloid membrane.

The *suspensory ligament* is a thin, transparent structure, extending from the zonula of Zinn, where it is continuous with the hyaloid membrane, to the anterior layer of the capsule of the lens.

The crystalline lens is devoid of blood-vessels and receives its nourishment from the ciliary body. In the fetus, a small branch of the arteria centralis retinæ is continued through the vitreous to the posterior capsule of the lens, where its branches radiate and join with those of the iris and pupillary membrane.

In the fetus the crystalline lens is almost spherical in form, slightly reddish in tint, imperfectly transparent, and extremely

soft. In the adult it is more firm, colorless, transparent, and convex on both surfaces. As age advances it becomes flattened, less elastic, more dense, slightly opaque, and somewhat tinted.

Vitreous Humor.—The vitreous humor, or body, is a clear albuminous fluid which forms about $\frac{4}{5}$ of the globe. It is hollowed out in front (hyaloid fossa) for the reception of the lens, and is inclosed in the hyaloid membrane. It is composed of water (98.5 per cent), with a few salts, and a little albumin. A delicate supporting reticulum extends through the vitreous, and this is particularly true in the fetus. There is a complete absence of blood-vessels in the adult, nutrition being derived from the retinal vessels and ciliary processes.

The *canal of Stilling, canal of Cloquet,* or ***hyaloid canal,*** is a canal extending in the fetus from the entrance of the optic nerve to the lens. It contains fluid, and is lined by a fold of hyaloid membrane. The canal of Stilling surrounds the atrophied remains of another canal, which, in the fetus, transmits a minute artery from the central artery of the retina to the capsule of the lens.

The *hyaloid membrane* is a delicate, transparent membrane investing the entire vitreous body and sending fibrous septa into the vitreous substance.

In front of the ora serrata it becomes thickened and is known as the zonula of Zinn. Here it is thrown into folds which are received in the depressions between the ciliary bodies to which it is adherent. Anteriorly the zonula splits into an anterior and a posterior layer. The posterior is thin and passes in front of the vitreous, lining the hyaloid or patellar fossa; the anterior, thicker and stronger, passes to the anterior part of the capsule, with which it blends, being called the suspensory ligament of the lens.

The angular interval between these layers of the hyaloid membrane at the circumference of the lens is the canal of Petit.

Muscles of the Eyeball.—The eyeball or globe is moved in various directions by the action of its muscles.

The muscles which effect its movements are the external rectus, the internal rectus, the inferior rectus, the superior rectus, the superior oblique, and the inferior oblique. These muscles are known as the extrinsic muscles of the eye.

Superior Rectus.—Origin: sheath of optic nerve and upper margin of optic foramen; insertion: into upper surface of sclerotic coat, 7.54 mm. from corneal margin; action: rotates the eyeball upward, with a tendency to an inward deviation which is corrected by the inferior oblique; nerve: third cranial or oculomotor.

Inferior Rectus.—Origin: from lower and inner part of the optic foramen (*ligament of Zinn*); insertion: into lower surface of sclerotic, 7 mm. from corneal junction; action: rotates the eyeball, with a tendency to an inward deviation which is corrected by the superior oblique; nerve: third cranial or oculomotor.

External Rectus.—Origin: by two heads—lower from ligament of Zinn and lower margin of sphenoidal fissure—upper from outer margin of optic foramen; insertion: into outer side of sclerotic 7.85 mm. from corneal margin; nerve: sixth cranial or abducens. The ophthalmic vein, the third, nasal branch of fifth and sixth nerves pass between the two heads of this muscle.

Internal Rectus.—Origin: same as inferior rectus; insertion: into inner side of sclerotic 6.91 mm. from corneal junction; action: rotates the eyeball inward; nerve: third cranial or oculomotor.

Superior Oblique.—Origin: from inner margin of optic foramen. Its tendon passes through a pulley near the internal angular process of the frontal bone. Insertion: into sclerotic between external and superior recti, midway between entrance of optic nerve and 17.9 mm. from the cornea; action: rotates eyeball on its anterior-posterior axis; nerve: fourth cranial or patheticus.

Inferior Oblique.—Origin: orbital plate of superior maxillary bone; insertion: outer part of sclerotic near the insertion of the superior oblique, and between the external and superior recti; 17 to 19 mm. from corneal margin; action: rotates the eyeball on its antero-posterior axis; nerve: third cranial or oculomotor.

ARTERIAL, VENOUS, AND LYMPHATIC SYSTEMS OF THE EYE

1. **Arterial.**—*a.* The short ciliary arteries (6 to 12 in number) enter through the sclerotic around the optic nerve to supply the choroid and ciliary processes.

b. The long ciliary arteries (2 in number) pierce the scle-

rotic, and run forward between the choroid and sclerotic to the ciliary muscles, which they supply. Here they form an anastomotic circle about the iris.

FIG. 10.—OPHTHALMIC ARTERY AND ITS DISTRIBUTION.

c. The anterior ciliary arteries (5 or 6 in number) enter the sclerotic in front, a short distance from the cornea, supply the ciliary processes, and anastomose about the iris.

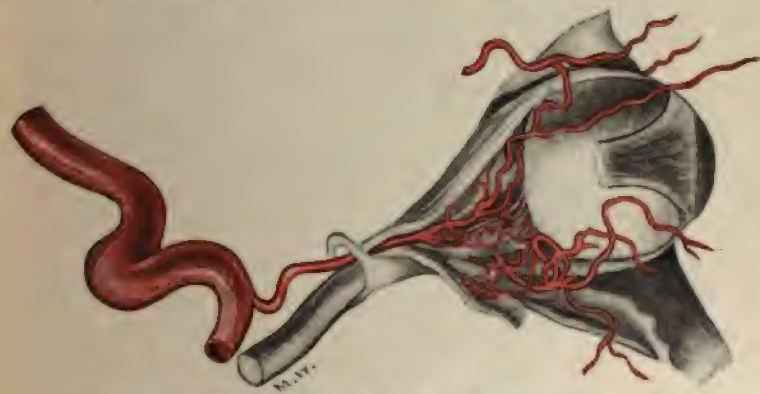


FIG. 11.—DEEP BRANCHES OF THE OPHTHALMIC ARTERY.

d. The arteria centralis retinæ supplies the retina, dividing into four or five branches, which enter the structure as deeply as the inner nuclear layer.

Muscular branches (2) supply the eyeball muscles. These arteries constitute the ocular branches of the ophthalmic artery.

The orbital branches of the ophthalmic are the lacrymal, supra-orbital, anterior and posterior ethmoidal, palpebral, frontal, and nasal.

The lacrymal supplies the lacrymal gland and gives off one or two malar branches, one passing through a foramen in the malar bone, the other appearing on the cheek and anastomosing with the transverse facial.

The supra-orbital passes out through the supra-orbital foramen to supply the surrounding structures.

The posterior ethmoidal descends through the posterior ethmoidal foramen to the ethmoidal cells and adjacent parts.

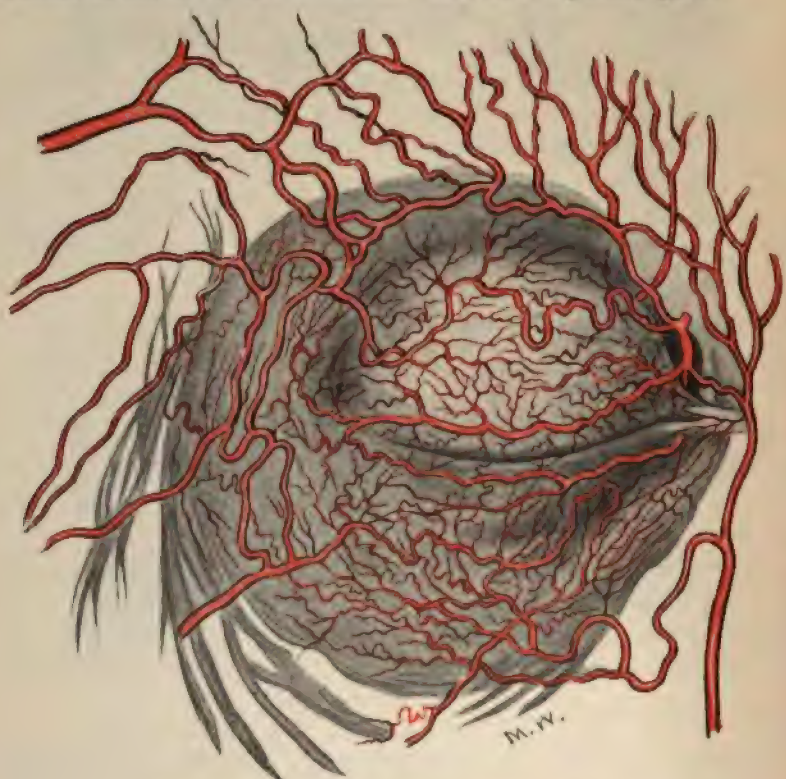


FIG. 12.—ARTERIAL SUPPLY OF THE EYELID.

The anterior ethmoidal passes through the anterior ethmoidal foramen and supplies the anterior ethmoidal cells and frontal sinus.

The palpebral arteries (2) supply the eyelids.

The frontal artery supplies the skin and muscles of the forehead.

The nasal supplies the lacrymal sac and bridge of the nose.

The other artery, supplying the eye and its appendages, is the infra-orbital branch of the internal maxillary.

FIG. 13.—OPHTHALMIC VEIN.

2. **Venous.**—The veins of the eyeball emerge through the sclerotic as the venæ vorticosæ, and unite with the other veins to form two main trunks—the superior and inferior ophthalmic veins—which terminate in the cavernous sinus. The ophthalmic vein anastomoses freely with the internal angular vein, the commencement of the facial, at the inner angle of the orbit.

3. **Lymphatic.**—The lymphatic system, consisting of lymph channels and lymph spaces, is divided into the anterior lymphatic system and the posterior lymphatic system. The anterior portion of the lymphatic system occupies the anterior and posterior chambers of the eye, which communicate by means of the pupil.

The lymph exudes from the posterior surface of the iris and the anterior surface of the ciliary body, while a small portion is

derived from the corneal endothelium and that of the ciliary processes.

The lymph is discharged from the anterior chamber of the eye by being filtered through the *ligamentum pectinatum* and spaces of Fontana into the *canal of Schlemm*, and thence into the epi-

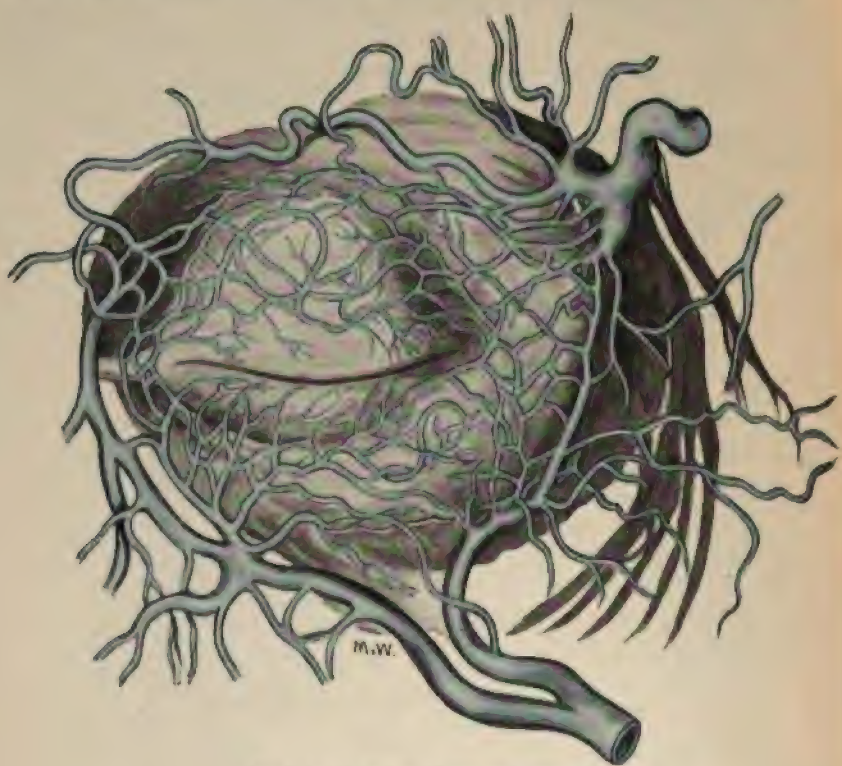


FIG. 14.—VEINS OF THE EYELID.

scleral lymph space, from which it is conveyed into the intracranial lymph spaces.

The posterior portion of the lymphatic system of the eye includes the hyaloid canal, the perichoroidal space, and the space of Tenon.

The blood-vessels of the optic nerve supply the lymph to the hyaloid canal, the vessels of the choroid to the perichoroidal space, and the vessels supplying the optic nerve and capsule of Tenon to Tenon's space.

The outflow of lymph from all the mentioned spaces is through the lymph passages which spread out along the optic nerve.

NERVES OF THE EYE

The nerves of the eye and its appendages are the nerve of the special sense of sight—the optic or second cranial; motor nerves from the third, fourth, and sixth cranial nerves; filaments of common sensation from the ophthalmic division of the trifacial or fifth cranial: and filaments from the sympathetic.

Optic Nerve.—This, the most important nerve of the eye, arises from the optic commissure, passing slightly upward, forward, and outward through the optic foramen into the orbital cavity of each eye. It is formed at the commissure by the decussation of the fibers of the optic tracts.

For convenience of study the optic nerve may be divided as follows:

1. Optic tracts.
2. Optic commissure.
3. Optic nerve.

The optic tract, at its connection to the brain, is found in two parts.

The inner, the smaller, passes underneath the internal geniculate body, with which it establishes a connection, and then through the posterior brachium to the posterior quadrigeminal body. Traced forward this part is found in the inner portion of the tract and on entering the optic commissure it crosses in the posterior part to enter the corresponding portion of the opposite tract.

The outer part is larger and separates into three portions: one enters the optic thalamus, another the external geniculate body, while the third passes through the anterior brachium to enter the superior quadrigeminal body. Traced forward, the innermost fibers of this part enter the commissure, and after crossing in its central portion pass to the inner side of the opposite optic nerve; the outer fibers pass through the external part of the commissure to occupy the outer portion of the optic nerve of the same side.

From the deep origin of the optic tract fibers pass to the cuneus, the cortical area of vision, while others pass to the nuclei

of the motor nerves of the eyeball. Further, some fibers are seen to pass directly to the cuneus from the optic tract and do not undergo interruption in the nucleus where the tract has its origin.

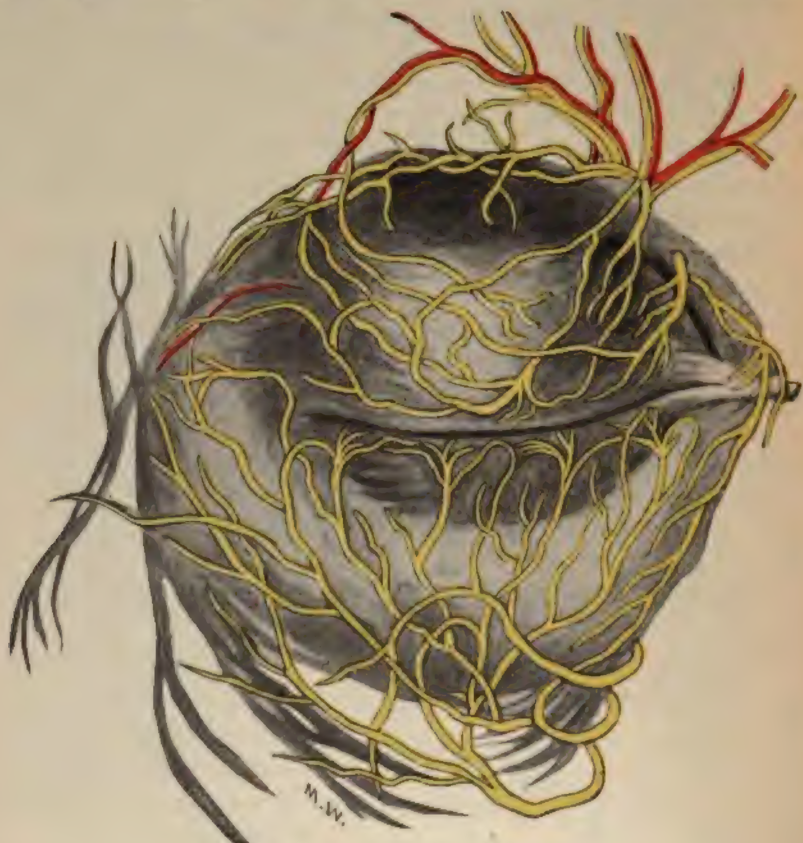
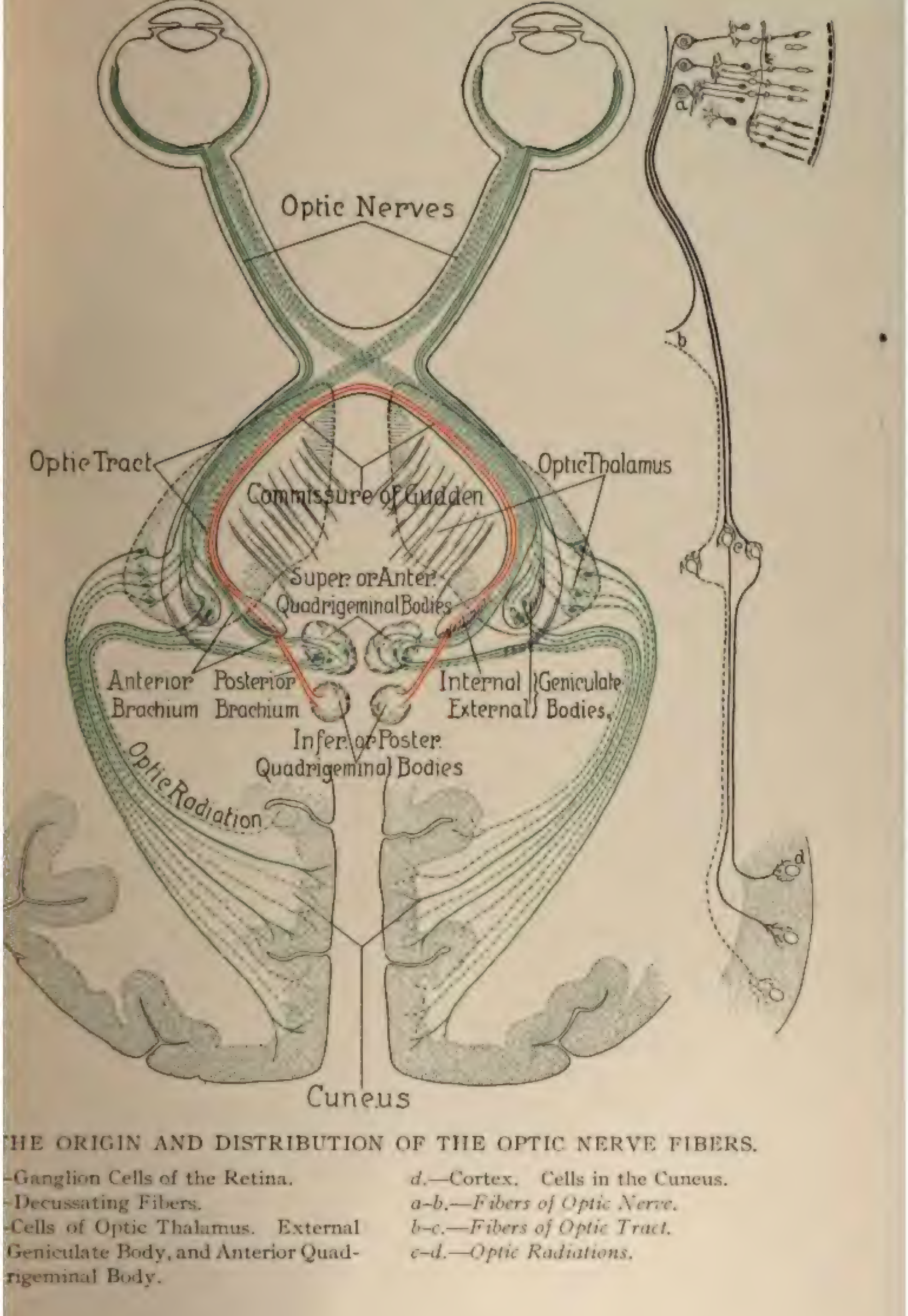


FIG. 15.—NERVES OF THE EYELID.

After the formation of the optic tract, it passes forward along the posterior inferior surface of the optic thalamus, crosses the crus, is connected with the tuber cinereum, and lamina cinerea, and in front of the infundibulum unites with the optic tract of the opposite side, thus forming the optic commissure or chiasm, which rests on the optic groove upon the superior surface of the sphenoid bone.

The optic commissure is made up of three groups of fibers, as follows:



THE ORIGIN AND DISTRIBUTION OF THE OPTIC NERVE FIBERS.

-Ganglion Cells of the Retina.
-Decussating Fibers.
-Cells of Optic Thalamus. External Geniculate Body, and Anterior Quadrigeminal Body.

d.—Cortex. Cells in the Cuneus.
a–b.—*Fibers of Optic Nerve.*
b–c.—*Fibers of Optic Tract.*
c–d.—*Optic Radiations.*

Decussating, longitudinal, and intercerebral fibers.

The decussating fibers, which are most numerous, form the central portion of the optic tract, are continued into the optic chiasm, where they decussate with similar fibers of the opposite tract, then entering the optic nerve on the opposite side are distributed to the nasal side of the retina.

The longitudinal fibers form the outer margin of the optic tract and commissure and are continued into the optic nerve of the same side, to be distributed to the temporal side of the retina.

The intercerebral fibers form the inner or posterior margin of the optic tract and run from one side of the brain to the other.

The optic tract, after it has passed behind the crus cerebri, is divided into an internal and an external portion, by a well-marked groove. The true optic fibers are in the external portion, having their origin as above mentioned. The internal portion is associated with the posterior corpus quadrigeminus and the internal geniculate body, the fibers being continued through the commissure passing from the optic tract of one side to the optic tract of the opposite side. These fibers are not concerned in vision, and constitute the commissure of Gudden.

Each optic nerve, from its origin in the optic commissure, passes forward slightly upward and outward to the optic foramen of its own side. The optic nerve may be divided into three parts, from without inward, as follows:

1. Intra-ocular portion, which is found within the sclerotic coat and is the termination of the optic nerve proper.

2. Orbital portion, which extends between the optic foramen and the globe.

3. Intracranial portion, or that portion extending between the optic foramen and the chiasm. This portion is inclosed in a sheath formed by the arachnoid. At the optic foramen the nerve becomes invested with an additional sheath, derived from the dura mater, which covers the portion of the nerve within the foramen. This latter covering subdivides into two layers as the nerve enters the orbit, one layer becoming continuous with the periosteum of the orbital cavity, and the other layer, together with the arachnoid, surrounding the optic nerve as far as the sclera. At the point where the optic nerve enters the globe it

becomes constricted in its diameter, at the same time losing its sheath, which becomes continuous with the sclera.

The fibers of the optic nerve pass through the openings in the sclera and choroid a little to the nasal side of the axis of the eye. They curve boldly round the margin of the latter foramen, and, spreading in all directions, form the anterior layer of the retina.

The arteria centralis retinæ enters the optic nerve just before the latter penetrates the eyeball, and is continued in a canal of fine fibrous connective tissue to the inner surface of the retina which it supplies. Venules accompany the artery from the eyeball.

The optic nerve is about 3 cm. in length and 4 mm. in diameter at its widest portion. Its function is to convey impressions of sight to the brain. It contains 500,000 to 1,000,000 fibers, each isolated by its medullary sheath.

APPENDAGES OF THE EYE

The appendages of the eye, or the *tutamina oculi*, include the following:

The eyebrows (supercilia).

The eyelids (palpebræ).

Conjunctiva.

Lacrymal apparatus: glands, ducts (7 to 10 in number), sac, and nasal duct.

The *eyebrows* are elevated arches of skin surmounting the upper margins of the orbits, covered with short, thick hairs.

The *eyelids* are two movable folds of tissue, covering and protecting the front of the eye. The upper lid is larger, longer, and more movable, being supplied with a special muscle, the *levator palpebræ superioris*.

The lids when opened are separated by an elliptical fissure (*fissura palpebrarum*) each angle of which is termed the outer and inner *canthus*, respectively.

The inner canthus is prolonged toward the nose for a short distance, and the lids in this position are separated by a triangular space, the *lacus lacrimalis*, at the outer angles of which are the *lacrimal papillæ*. The apex of each papilla is pierced by the *punctum lacrimalis*, the beginning of the lacrymal canal. The lacus

lacrimalis is filled by the *caruncula lacrimalis*, a mass of follicles resembling the Meibomian glands, and covered by the conjunctiva.

The structure of the eyelids from without inward is as follows:

Skin.
Subcutaneous areolar tissue.
Fibers of the orbicularis muscle.
Tarsal plates.
Fibrous membrane (tarsal ligament).
Meibomian glands.
Vessels and nerves.
Conjunctiva.

The skin is thin, being attached by a very loose areolar tissue to the muscle beneath.

The fibers of the orbicularis palpebrarum are pale, thin, and act involuntarily as well as voluntarily.

The tarsal plates—two in number—are composed of dense connective tissue; the superior, the larger, is semilunar in shape, the inferior is elliptical. The inner margins are fixed to the orbit by the *tendo oculi.*

The fibrous membrane of the lids, or tarsal ligament, passes over the anterior surface of the tarsal plate, being attached to the free margin of the latter below and to the malar bone externally.

The Meibomian glands in the upper lid number about thirty; they are somewhat fewer in the lower lid. They are arranged vertically on the inner surface of the cartilages, and are straight sebaceous glands into which a number of secondary follicles open. They terminate above in a blind extremity, opening below, on the free margin of the lids, by small foramina corresponding to the number of tubules.

The eyelashes, or cilia, are arranged on the free border of the lids in two or three rows.

The conjunctiva, the mucous membrane lining the eyelids, is reflected over the cornea and anterior portion of the sclera. It consists of two portions: the ocular portion, which is reflected over the sclera and cornea, and the palpebral portion, which lines the internal surface of the lids.

The ocular portion is loosely connected with the sclera, but

over the cornea it becomes firmly adherent. In the latter position it consists only of the epithelial layer.

The palpebral portion is thick, highly vascular, and contains many papillæ. At the inner angle of the eye it forms a semilunar fold, the *plica semilunaris*—the rudiment of the nictitating membrane of birds, the *membrana nictitans*.

The point of reflection from the eyelids to the eyeball is called the *fornix conjunctivæ*, and the reflected portions the *superior* and *inferior palpebral folds*.

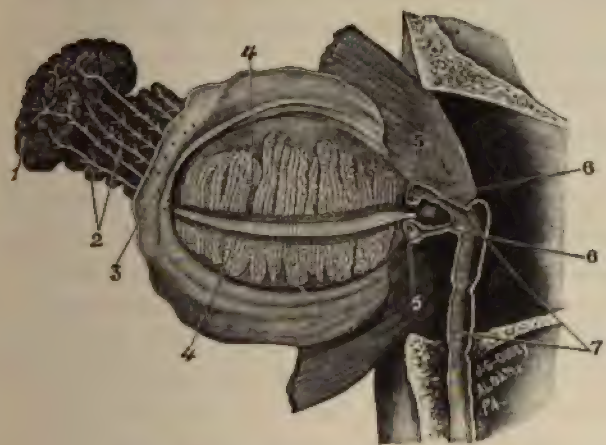


FIG. 17.—LACRYMAL APPARATUS.

1. Lacrymal gland. 2. Excretory ducts. 3. Mouth of excretory ducts. 4. Meibomian glands. 5. Puncta lacrymalia. 6. Lacrymal canaliculi. 7. Lacrymal sac and nasal duct.

The lacrymal apparatus consists of the lacrymal gland and its ducts, the lacrymal sac, and nasal duct.

The lacrymal gland is an oval, glandular body, about the shape and size of an almond, situated in a depression at the upper outer angle of the orbit, on the inner side of the external angular process of the frontal bone.

The anterior portion of the gland is sometimes described as a separate lobe—the *palpebral portion of the gland* or *accessory gland of Rosenmüller*.

The gland is attached to the bony roof of the orbit by the tarso-orbital fascia.

The ducts, 7 to 10 in number, open by minute orifices arranged in a row upon the conjunctiva near its point of reflection.

The lacrymal canals commence at the puncta lacrymalia, at the summits of the papillæ lacrymalis, and empty by two canaliculi into the lacrymal sac.

The superior canal at first ascends and then descends obliquely inward and downward, while the inferior descends at first and then passes nearly horizontally inward.

The lacrymal sac is the oval, dilated, upper portion of the nasal duct lodged in a deep groove formed by the nasal process of the superior maxilla and the lacrymal bone. It is crossed by the *tensor tarsi muscle* (sometimes called Horner's muscle), which acts as a compressor, and receives a fibrous expansion from the tendo oculi.

It is made up of a fibro-elastic coat, lined by mucous membrane continuous with that of the nose and conjunctiva.

The nasal duct is a membranous tube about 2 cm. in length, extending from the lacrymal sac to the inferior meatus of the nose, and lining the bony lacrymo-nasal canal. It passes backward, downward, and outward, and is protected at its inferior extremity by a valve composed of mucous membrane—the valve of *Hasner*. The mucous membrane is continuous with that of the sac, but instead of having squamous epithelium the latter is ciliated in the duct.

CHAPTER III

EXTERNAL EXAMINATION OF THE EYE

General Considerations.—As in other departments of medicine, a systematic record should be kept of each case. Besides the data of identification, such as name, residence, etc., the family and personal history, as well as the occupation and habits of the patient, should be carefully investigated. The circulatory, respiratory, digestive, as well as genito-urinary organs, often furnish their share of valuable information in the history. The nervous system especially should be subjected to careful scrutiny. Wherever constitutional involvement is suspected, a thorough analysis of the urine should be made.

The conformation of the skull and the position of the orbits should be inspected as to whether there be symmetry or asymmetry. The tension of the eyeball should always be carefully investigated. (See Glaucoma.)

Examination of the Eyelids and Conjunctiva.—The former should be examined for their position and motility, whether they are in proper apposition when closed, together with the general appearance of the palpebral fissure. By these methods of inspection we will be able to observe entropion an ectropion, ptosis, lagophthalmos, blepharospasm, and blepharophimosis. The borders of the lids should be carefully inspected for crusts, scales, secretion, parasites, tumors, and malposition of the eyelashes (triachiasis or distichiasis). The position of the puncta lacrymalia should be especially observed. The skin of the lids should be examined for scars, wounds, inflammation, edema, and cutaneous lesions, it being remembered that the skin of the eyelid is a portion of the general integument, and therefore liable to be the seat of cutaneous involvement elsewhere. When the eyelids are firmly glued together they should first be carefully freed from accumulated secretion with a pledget of cotton wet with warm boric-acid solution,

or peroxid of hydrogen. Forcible separation should never be performed, not only for the patient's sake, but in order to prevent a sudden spurt of secretion from infecting the eyes of the examiner. Careful palpation should distinguish between edema and emphysema. The inner canthus should be carefully inspected and palpated for the presence of fistulæ, tumors, inflammation, mucus, pus, or an abnormal collection of tears. A pressure over the region of the lacrymal sac may dislodge products of inflammation into the conjunctival sac. If doubt exists as to whether the lacrymal passages are patulous, the injection of a few drops of a warm normal salt or boric-acid solution into the canaliculi will run freely into and out of the nose if no obstruction exists.

The under surface of the lids should now be inspected. In the case of the lower lid it is simply necessary to request the patient to look upward and to gently draw down the lower lid with the thumb. To inspect the inner surface of the upper lid it is necessary to evert the same. This is accomplished by requesting the patient to look downward, grasping the eyelashes of the upper lid between the right thumb and index finger; a small amount of gentle traction is then made in order to slightly stretch the skin of the lid, and the index finger of the left hand with the dorsal surface inward when facing the patient is then gently applied to the surface of the lid, about 2 cm. above its margin, pressure gently exerted at that point, and the lid lifted, the finger acting as a fulcrum; the lid finally turns upon the cartilage. In refractory patients a match stick or glass rod can be used instead of the finger. The lid having been everted, it is inspected for scars, trachoma granules, foreign bodies, tumors, inflammation, symblepharon, secretion, etc. It must not be forgotten that the *retrotarsal fold* should also be carefully looked after by bringing that structure into view, either by means of a glass rod or a Noyes retractor. It is especially in the retrotarsal fold that pathological processes, as diseased follicles and calcareous deposits, often remain undetected. The greatest care must be exercised in handling the lids that are the seat of fissures or which are glued together by secretion, as they may hide pathological processes of the eyeball that might be aggravated by unskillful external manipulations. *The ophthalmic surgeon should educate himself to acquire that delicacy of touch and gentleness*

of manipulation so essential to the eye as well as to the patient. Indeed, the patient will frequently be docile or refractory, in proportion to the skill rather than the force exercised by the surgeon. In the case of infants or nervous children, the head of the patient had better be gently yet firmly secured between the knees of the surgeon, while an attendant holds the lower portion of the child's body on the lap. By this means an unobstructed view of the eyes is obtained, and both hands of the surgeon are free.

The palpebral conjunctiva having been examined, the bulbar conjunctiva is inspected for vascular injection, its character and location, for pigmentation, adhesions, phlyctenules, tumors, hypertrophies, foreign bodies, cicatrices, etc. At the same time the size and position of the eyeball within the orbit can be determined.

Examination of the Sclera.—This structure is white, except in elderly people, where it often presents a yellowish hue. In young children it may be slightly bluish. The structure should be inspected for evidences of previous injury, staphyloma, nodules of scleritis, or the circumscribed patches often occurring in this affection. Where there has been an attack of the classical circumscribed inflammation, the original site of the process will often remain identified as a distinctly violaceous discoloration surrounding the whole cornea.

Examination of the Cornea.—Normally the cornea is transparent. The structure can be examined by direct light or by oblique illumination, which consists of focusing the light with a high convex lens upon the cornea and then viewing it through a similar lens. Examination should then be made for loss of transparency, irregularity of surface, abrasions, ulcers, blood-vessels (in health the cornea has no blood-vessels), interstitial inflammation, and protrusion. The cornea varies in size, the average horizontal diameter, according to Priestley Smith, being 11.6 mm. The sensibility of the cornea is determined by very gently touching its surface with a point of a small piece of absorbent cotton, care being taken that none of the fibers of the cotton come in contact with the conjunctiva. If the sensibility of the cornea is intact, winking of the lids will take place as soon as the cotton touches it (*palpebral reflex*). Sensibility of the cornea is decreased or absent in glaucoma, and in some affection of the trigeminus.

The Fluorescin Test.—This valuable test consists ir into the eye a solution of fluorescin rendered alkalis addition of sodium carbonate or liquor potassa (see which does not affect that part of the cornea which is i: will color green those portions denuded of epithelium, the epithelium is diseased. Cocain enhances the powe fluorescin. Minute alterations in the structure in the co often be detected by means of Jackson's or Berger's b magnifier, or de Zeng's corneal microscope.

Examination of the Anterior Chamber.—This con: investigating its depth, contents, and relation to surroı structures. When normal it has an average depth of 2.(Its depth is increased in luxation of the lens, absence of th((aphakia), protrusion of the cornea, retraction of the iris b; adhesions, and serous cyclitis. The anterior chamber is sha in glaucoma, bulging of the iris, swelling of the lens, intra-o(tumors, and in very flat corneæ.

Normally, the aqueous humor is clear; pathologically, its tents may become turbid from iritis, serous cyclitis, glauc foreign bodies, or other forms of traumatism. The patholo contents may be blood (hyphema), pus (hypopyon), or l; exudate. It may contain foreign bodies or parasites.

Examination of the Iris.—This can only be accomplish the cornea and aqueous humor are transparent. The color, ation, and configuration of the iris should be noted, and espe(the presence of adhesions. Bulging of the iris may be dı an intra-ocular tumor, foreign body, or an infiltration of th(with gummata. The irides may vary in color (heterochro or there may be a difference in the coloration of a single iris so-termed piebald iris. Pathological discoloration is gene due to iritis or cyclitis. The iris is greenish brown in side

The examination of the lens, vitreous, choroid, retina, nerve, and extra-ocular muscles will be considered in the (ters devoted to those structures; likewise the examination o visual fields, functional testing, etc.

diluted aqueous solution of grindelia robusta (1–10) is often employed. The inflammation terminates favorably in a few days.

The eyelids may also be the seat of drug eruptions (*dermatitis medicamentosa*).

Blastomycosis, a cutaneous affection due to a parasitic fungus in the skin, may at times be encountered on the eyelid. It consists in well-developed cases of an irregular elevated area of a more or less deep red or purplish color, made up of papillomatous formations and studded with numerous small discharging abscesses. Scarring may be observed at the border where healing has taken place. While this is essentially a skin disease, it is often first detected by the ophthalmologist on account of its predilection for the region of the eye. The treatment consists in the administration of the iodids and the extirpation of the diseased tissue.

FIG. 18.—BLASTOMYCOSIS OF THE EYELID. (Author's case.)

Abscess of the eyelids most frequently follows some traumatism to the eye or adjoining structures, with infection.

All the symptoms of inflammation and suppuration are present. Compresses moistened in hot boric-acid solution should be employed to hasten maturation, if seen early, and an incision should be made parallel to the muscle fibers as soon as fluctuation is detected.

Furunculosis consists of a local infection of one or more of the hair follicles by staphylococci, and is much benefited by the application of ichthyol, 1 dram (4.0) to the ounce (32.0) of lanolin. Incision should be made as soon as suppuration has occurred.

Erysipelas may affect the eyelids as a part of erysipelas of the face, and is characterized by heat, pain, redness, vesication,

and a sharply defined edge which is elevated above the surrounding skin. It is attended by swelling and edema, which may render opening of the lids impossible. Chilliness, malaise, headache, anorexia, and fever (102° to 105° F.) are nearly always present. The affection seldom lasts more than four or five days, and tends to recur. Its presence contra-indicates any operation upon the eyes or appendages.

The **treatment** consists largely in the internal administration of quinin, tincture of the chlorid of iron, strychnin, and the stimulants to maintain the resistance of the system. Locally, weak solutions of nitrate of silver, 1–2,000 chinosol, or washing with soap and water, then 1–2,000 bichlorid-of-mercury solution, followed by twenty-five per cent ichthyol ointment in petrolatum are of benefit.

Anthrax Pustule.—Animals infected with anthrax convey the disease to man by inoculation. It very frequently affects those persons whose employment brings them in contact with the infected animals (tanners, furriers, wool sorters). Extensive tissue destruction often results. The *treatment* consists of antiseptic fomentations, excision of the affected areas, and later plastic operations if tissue destruction has resulted. Constitutional measures should not be forgotten.

Herpes zoster ophthalmicus is an unusual affection of the lids, and possesses the characteristics of herpes zoster elsewhere. The condition is acutely inflammatory, and is manifested by the formation of papules, having on the apex of each papule a vesicle, grouped together along the course of the supra-orbital nerve and accompanied by excruciating neuralgic pains, particularly before the appearance of the eruption. The vesicles show no tendency to spontaneous rupture, and involve but one side of the face at a time. They dry in one or two weeks and fall off, not infrequently leaving scars. In rare cases the blisters may become pustular, hemorrhagic, or gangrenous. Involvement of the cornea and iris may occur, resulting in their destruction. The disease is due to some neurotic disturbance. Microscopically the skin affected shows that the vesicles develop in the rete mucosum; the papillæ of the skin are enlarged and the blood-vessels dilated. There is also new cell proliferation extending even into the corium and subcutaneous tissue. The nerves at the site of the erup-

tion are inflamed with cell infiltration of the neurilemma, the ganglia of the sensory nerves are inflamed, and may be the seat of cell infiltration. In serious cases the ganglia have been found in an entirely altered and softened condition. The chief causes are exposure to cold draughts, atmospheric changes, and injury

FIG. 19.—HERPES ZOSTER OPHTHALMICUS. (Author's case.)

to the nerves from direct blows or pressure. Herpes may also occur in consequence of certain diseases, as malaria, influenza, pneumonia, typhoid fever, Pott's disease, and the inhalation of carbonic oxid. Among the predisposing causes are nerve fatigue and exhaustion, local irritants, and a delicate susceptible skin.

Treatment is directed largely toward the relief of pain. Acetphenetidinum and other coal-tar derivatives may be administered, but frequently morphin is necessary. The bowels should be well cleansed out and diaphoretics given to stimulate the skin. Internally, the following formula may be given with beneficial results in capsule form three times daily for a period of one to two weeks:

℞ Strychninæ sulphatis	gr. ss;	0.03
Ferri pyrophosphatis solubilis.....	gr. xl;	2.50
Arseni trioxidi	gr. ⅓;	0.02
Quininæ bisulphatis	gr. xx;	1.20
Aloini	gr. jss;	0.10
Extracti gentianæ	gr. xl;	2.50

Misce: et pone in capsulas No. xx.

Sig.: One capsule after each meal and at bedtime (Shoemaker).

Locally, flexible collodion, containing 10 grains (0.6) of morphin to the ounce (30.0), may be employed, or dusting powders of zinc oxid, starch, talc, etc., may be used. The following lotion will often be sufficient to stop the pain, assist in drying up the vesicles, and cut short the progress of the disease:

℞ Tincturæ opii	℥j;	30.0
Alcoholis absoluti	℥jss;	45.0
Aquæ ....q. s. ad. fl	℥viij;	240.0

Misce. Sig.: Saturate two layers of gauze and apply locally to the affected parts. The gauze should be kept moist and evaporation allowed to produce a cooling as well as an anodyne effect.

The following history (Fig. 19) illustrates the **course** of the disease in a typical case treated by the author:

Prodromal Symptoms.—Patient would wake up in the morning with frontal headache which would wear off in the course of the day, occasionally persisting until nightfall, when it would become intense. These headaches were distinctly nervous and would be frequently relieved by applications of moderate heat to the head.

Three days before the onset of the severe attack of the disease, a small cluster of vesicles about an inch in diameter made their appearance on the temple near the outer canthus of the right eye. These blisters were unaccompanied by local pain, but the patient now suffered with persistent headache. The severe symptoms of the disease began on the third day following the appearance of

the first group of vesicles, and were ushered in by successive crops forming along the course of the supra-orbital nerve, covering the entire right frontal region, extending to the eyelid and involving the cornea of the right eye. This eruption was accompanied by considerable local inflammation—photophobia and excruciating neuralgic pain. The entire eye was involved, exhibiting pronounced scleritis with the vesicles on the outer half of the cornea. The intra-ocular tension was increased.

The disease reached the fastigium on the sixth day after the appearance of the first crop of vesicles, the patient manifesting signs of exhaustion from the constant unrelenting neuralgic pain that involved the entire right half of the head, and from lack of sleep. But for the free use of opiates and constant bathing with ice-cold lotion, the patient's condition would have been pitiable.

The severe symptoms began to abate on the sixth or seventh day, and by the ninth day the patient was nearly free from distress, except for an occasional twinge of neuralgic pain, the inflammatory condition subsiding, the vesicles becoming slightly pustular, drying and falling off in the course of ten or twelve days, leaving slightly pigmented scars. The vision of the eye was much impaired, distorted, etc., for several weeks. The entire right frontal area was left in a condition of marked anesthesia, as was also a considerable portion of the right cornea, this anesthesia, persisting for several months and gradually subsiding.

Diagnosis.—From the history of the onset, such as unilateral neuralgic pains, without any known cause, in the area involved, and followed by inflammatory papules having a vesicle on the apex of each papule: also, that the papules appeared in groups, and that the vesicles have no tendency to rupture—are all sufficient symptoms that the disease is herpes zoster ophthalmicus. The lesions are so typical that it could not be mistaken for any other disease, but at the very onset, when the papules appear with the small vesicles on the apices, the disease may be confounded with eczema, and in its later stages with vesicular eczema.

The *differential diagnosis* between *herpes zoster* and *vesicular eczema* is as follows:

Herpes Zoster	*Vesicular Eczema*
1. History of premonitory pains preceding the eruption.	1. History of itching and burning sensation at the onset of the eruption.
2. The eruption is unilateral along the cutaneous nerves and in separate groups.	2. The eruption is bilateral and symmetrical and not definitely arranged.
3. The vesicles are situated on an inflammatory base, are large, and show no tendency to rupture.	3. The vesicles are situated on a slight erythematous base, are small, and rupture spontaneously.
4. Vesicles dry up.	4. Vesicles rupture, weep, and form crusts.
5. Pain increased on pressure.	5. Pain is not increased on pressure.

Eczema of the eyelids is a very common affection, and is usually erythematous in character, although the other varieties of the disease may occur. It is most frequent in those past middle life and in individuals who are exposed to high degrees of heat and cold. Irritants of various kinds are responsible for it. The disease is worse in winter and is chronic in nature, showing a marked tendency to relapse. It begins as bright or dull-red spots, the margins of which are ill defined, to be followed by coalescence with the production of a diffusely reddened area. The intensity of the inflammation may induce edema of the loose areolar tissue, causing closure of the eyelids. In this respect it resembles erysipelas, but the absence of constitutional disturbances and the other symptoms will serve to distinguish it. The itching is intense and is aggravated by scratching.

Treatment consists in the withdrawal of all irritants, and the use of soap and water in this situation should be especially interdicted. Sedative lotions, such as the following, are of great value:

℞ Acidi borici	gr. xlv;	2.6
Glycerini	♏xxx;	1.8
Aquæ camphoræ	fl ℥iij;	90.0

Misce. Sig.: Apply locally three or four times daily.

Or,

℞	Resorcinolis	gr. xx;	1.3
	Glycerini	♏xxx;	1.8
	Liquoris calcis	fl ℥ij;	60.0

Misce. Sig.: Apply locally three times daily.

Or,

℞	Glyceriti boroglycerini (25 per cent)	♏x;	0.6
	Unguenti aquæ rosæ	ʒj;	4.0

Misce. Sig.: Apply locally three or four times daily.

Bismuth subnitrate or zinc oxid, ʒj (4.0), may be substituted for the boric acid for protection after the evaporation of the aqueous element of the lotion. Yellow oxid of mercury, gr. ss (0.031) to ʒj (4.0) of petrolatum, is also beneficial in some cases.

Ulceration of the eyelids is usually due to some condition, such as syphilis, lupus, or epithelioma, but occasionally is seen as an independent affection. In a case of the author's, the condition followed contact with the discharge from chancroids and condylomata in the female genital region, the infective material being carried to the eyelids by the finger. Ulceration of the eyelid followed within four days after inoculation, and extension to the other ocular structures induced purulent conjunctivitis and corneal ulceration. The discharge was profuse and produced secondary ulceration of all portions of the face with which it came in contact. The treatment consisted in protecting the unaffected eye by means of a Buller's shield, after which the ulcerated lesions were thoroughly scraped and cauterized with a 50-per-cent solution of trichloracetic acid. Antiseptic lotions were used at frequent intervals to destroy the infection. Three weeks later the skin of the face and eyelid resumed its normal appearance with but very slight scarring, but the cornea became very opaque, rendering the eye useless as a visual organ.

Vaccine ulcers may occur on the eyelid as the result of inoculation by the finger, and may be accompanied by fever and involvement of the pre-auricular glands.

Blepharitis (*Sycosis tarsi; Blepharo-adenitis; Blepharitis ciliaris*).—This inflammation of the margin of the lids is the most common affection to which those structures are liable. It arises from a number of causes, the most frequent being uncorrected

ametropia. . Less common factors in its production are inflammatory conditions of adjacent structures, such as eczema of the lids and face, conjunctivitis, keratitis, inflammation or degeneration of the roots of the eyelashes, pediculi, uncleanliness, and constitutional disturbances such as attend tuberculosis and syphilis.

Two varieties of blepharitis are recognized: *squamous* and *ulcerative*.

Squamous blepharitis is the milder form, and is characterized by redness and scaliness of the lid margins, attended by intense itching and burning, aggravated by prolonged use of the eyes and exposure to bright light for any length of time. During sleep the inflammatory exudate accumulates so that on awakening the lids are found glued together by yellowish gummed secretion. Upon separating the lids, the secretions dry in the form of crusts and scabs. The laity confuse this condition with true trachoma, and speak of it as "granulated eyelids." According to Fuchs, it may be regarded as a seborrhea.

Ulcerative blepharitis differs from the former variety only in the degree of intensity of the inflammation. The crusts are larger, and upon removal reveal small excavated ulcers. The involvement of the hair follicles and their sebaceous glands leads to falling out and dwarfing of the cilia. This loss of the eyelashes gives rise to more or less deformity, and is known as *madarosis*. The continuance of the inflammation may cause an abnormal hypertrophy of the lids, which leads to their eversion. The red, thickened edges are then exposed to view, constituting "blear eye," or *lippitude*. The eversion also affects the lacrymal puncta, so that an overflow of tears, or epiphora, is almost constant. The condition is a true eczema (J. Herbert Parsons).

The **treatment** of this condition should be routine, and should take into consideration all portions of the eye and lacrymal system, as sometimes the most trivial ocular affections may cause its persistence if untreated. The removal of crusts by means of hot water, petrolatum, sweet oil, or the ointment of boroglyceride is the first indication. Diseased eyelashes should be extracted with cilia forceps, and any small ulcerations should be touched by silver-nitrate solution (10 per cent) or the mitigated stick. A boric-acid solution should be used freely to prevent the accumulation of the exudate in the conjunctival *cul-de-sac*, and also for its effect

[illegible] conjunctivitis. The refraction should be care- [illegible] under atropin mydriasis and the correction or- [illegible] use. Frequently the instillation of a mydriatic [illegible] prompt subsidence of the symptoms. Obstruction [illegible] ducts should be sought for, as the epiphora may be a [illegible] as the result of the blepharitis. The following [illegible]:

℞ [illegible]	....	gr. viij;	0.5
[illegible] } [illegible]	....	āā ʒss;	2.0
[illegible]	....	ʒijss;	10.0

[illegible] Apply locally at night.

[illegible] conditions should receive treatment such as [illegible] recommended under eczema of the lids. In individ- [illegible] general health is below par, cod-liver oil, sirup of the [illegible] and similar tonics are indicated.

Impetigo contagiosa sometimes occurs on the eyelids, and re- [illegible] use of a weak ammoniated mercury ointment, gr. x [illegible] of petrolatum, for its relief.

Edema of the eyelids is nearly always bilateral, and is due to [illegible] disease of the heart, liver, or kidneys, but may be unilateral [illegible] inflammatory or traumatic conditions, such as [illegible] stings, etc. Edema upon arising in the morning is [illegible] first symptoms of renal dropsy. Indicanuria and [illegible] coexist, in which case autointoxication should be [illegible] Angioneurotic edema, and that due to the adminis- [illegible] drugs, especially the iodids, and disturbances of the [illegible] may also occur in this situation, and is usually [illegible] Persistent edema may be due to syphilis.

The **treatment** should be directed toward the underlying con- [illegible] occasionally the tension upon the skin is so great as [illegible] multiple punctures. The following lotion has proved [illegible] beneficial in cases of edema:

℞ Acidi borici	....	ʒj;	4.0
Spiritus vini gallici, } Alcoholis,	....	āā fl ℥ij;	60.0

[illegible] Sig.: Use locally.

Psoriasis is a very rare condition of the skin of the eyelids characterized by hyperemic patches covered by imbricated mother-of-pearl scales. The removal of the scales reveals a superficial inflammation of the skin. Psoriasis of the face is always an accompaniment. Stimulating ointments are advisable, and internal medication is necessary. Arsenic internally is of value. In this situation the disease is obstinate, and should not be mistaken for affections of the lids due to eyestrain.

DISEASES AFFECTING THE GLANDS OF THE LIDS

Seborrhea, a functional disease of the sebaceous glands, sometimes involves the eyelids as a part of a seborrhea of the head and face. It has no connection with blepharitis. It is characterized by scaliness or oily secretion. A weak sulphur ointment, 30 grains (2.0) to the ounce (32.0) of petrolatum, is very beneficial in this condition.

Milium is another disease of the sebaceous glands that attacks the eyelids. It is characterized by small yellow or pearly white round bodies beneath the epidermis. They are translucent and slightly elevated above the skin. Calcareous degeneration may occur, resulting in cutaneous calculi. The cause is unknown. Removal is indicated, and it may be accomplished by puncturing and touching the exposed sac with nitrate of silver, electrolysis, or pressure. Large accumulations of sebaceous matter in the glands constitute sebaceous cysts or wens.

Hyperidrosis, or excessive sweating, may occur upon the eyelids as the result of some neurotic disturbance. It is a functional condition due to abnormal activity of the sweat glands, and is most marked in unilateral sweating.

Chromidrosis of the palpebral region is another disorder of the sweat glands characterized by patches of pigmentation on the skin, especially of the lower lid. It is most frequent in females, and may be removed by oil or glycerin, but promptly returns. It is more or less periodic in character, and its cause is unknown. The affection is simulated sometimes by hysterical individuals.

Hydrocystadenoma is a still rarer affection of the sweat glands, and is also seen upon the eyelids. It is noninflammatory, and is characterized by translucent, deep-seated, persistent vesicles resembling sudamina.

AFFECTIONS OF THE MEIBOMIAN GLANDS

Chalazion.—This is a chronic inflammation known as *Meibomian cyst, chalazion, tarsal cyst,* and *tarsal tumor.* It may terminate by ulceration through the skin or conjunctiva with partial evacuation of the cyst, or it may become calcified and ulcerate through at a later period. The latter termination is more frequent in gouty individuals, and in such persons these glands are often the seat of tophi. They are most common in adults who subject their eyes to considerable strain in consequence of some error of refraction. There may be one or more present at the same time, and they require a rather long period for the completion of their course. They are first noticeable by the hard swelling beneath the skin and in the upper lid, adherent to the tarsal cartilage. Rupture is indicated by the adjacent inflammation and by the small mass of granulations on the conjunctival surface over the tumor. Occasionally they disappear spontaneously, but usually they induce considerable conjunctival irritation and corneal astigmatism by pressure. Pathologically the growth is a granuloma (J. Herbert Parsons). Nontubercular giant cells have been found.

The **treatment** varies with the size of the cysts. When small the ametropia should be corrected and massage of the lid with yellow oxid-of-mercury ointment, 1 grain (0.06) to the dram (4.0), should be practiced once daily at least. Larger ones should be removed. To accomplish this the lid should be fixed by a Desmarre's chalazion forceps, so that the ring blade of the forceps encircles the tumor. The forceps is tightened and the tumor is bisected by a sharp scalpel or a Beer's knife. The contents are evacuated by a small especially devised chalazion curette, at the same time destroying the cyst wall. The incision should be made from that side of the lid to which the tumor seems nearest, and an aseptic dressing and bandages are applied. A favorite method of the author's is to incise the cyst vertically upon the conjunctival surface, after which a small curette is introduced and all the contents are removed and the cyst wall entirely broken up. The vertical incision preserves the integrity of the gland.

Hordeolum, or stye, is a furuncular inflammation attacking the follicles of the eyelashes, involving Zeiss's glands when of the

external or more frequent variety, and involving the Meibomian glands (*Meibomianum*) when *internal*. It begins as a small red swelling at the margin of either lid, and is attended by tenderness, pain, edema, and impairment of vision. The affection may subside or remain stationary for an indefinite period, but more frequently it terminates in suppuration, which is indicated by the yellowish point at the summit of the lesion. The cause of styes is the infection of the hair follicles by pus-producing micro-organisms in eyelids congested as the result of ametropia or some derangement of the general health. They occur at all ages, but are most common in young adults, in whom they often show a tendency to come out in crops.

The **treatment** varies according to the stage of the inflammation. Attempts may be made to abort the lesion by the constant application of cold compresses, repeated applications of collodion, boric-acid solution, and the administration of calcium sulphide in $\frac{1}{8}$ grain (0.008) doses every hour until a physiological effect is produced. The benefit derived from such measures in this connection is doubtful. A better method of treatment is to hasten suppuration by the application of hot compresses, alone, or wrung out in the following solution:

℞ Liquoris plumbi subacetatis	fl ʒij;	8.0
Tincturæ opii, Tincturæ belladonnæ,	āā fl ℥jss;	6.0
Tincturæ arnicæ	fl ℥j;	30.0
Aquæ camphoræ, Aquæ destillatæ,	āā q. s. ad. fl ℥iv;	120.0

Misce. Sig.: Poison. Use locally as directed.

The appearance of the yellow spot at the summit of the lesion calls for evacuation of the underlying pus. This may be accomplished by removing the hair in the center of the stye or by a vertical incision through it. A weak antiseptic dressing should then be applied. Sometimes an ointment containing ichthyol, 1 dram (4.0) to the ounce (32.0), seems to be of special value in this condition. In all cases a careful examination should be made of the refraction, as recurrences are common in the presence of ametropia. Tonics, such as iron, quinin, strychnin, and cod-liver

oil, are sometimes necessary when the affection persists. The presence of constipation should be ascertained, and appropriate treatment directed toward it, as it is a contributory factor in many cases.

AFFECTIONS OF THE EYELASHES

Alopecia areata, a neurotic disease of the hair follicles which induces partial baldness in atrophic areas, sometimes attacks the eyelashes, causing them to drop out more or less suddenly without any local structural change to account for it. The skin is smooth, soft, and of a dead-white color. The condition is most common in children and young adults, and the hair in these individuals usually returns after a period of three or four months. The new hairs are at first devoid of pigment and resemble down, but later assume their normal characteristics.

The **treatment** consists in the administration of arsenic in varying doses, according to the age of the patient and the local application of the faradic current, or the following eyelash tonic:

℞ Quininæ sulphatis	gr. v;	0.3
Olei rosæ	q. s.	
Olei amygdalæ expressi...........	℥j;	30.0

Misce. Sig.: Apply daily with a fine brush.

The close proximity to the cornea contraindicates the local application of alcohol, capsicum, cantharides, and similar irritating preparations usually advised for this affection in the scalp.

Pediculosis ciliorum (*Phthiriasis palpebrarum; Blepharitis pediculosa*) is a parasitic affection of the eyelashes produced by the pediculus pubis, or crab louse. It is the smallest variety of the pediculus, and is found at the roots of the cilia with the head buried in the follicle. The shafts of the eyelashes are covered with the ova, or "nits," which are fastened very firmly to them. The affection induces itching and burning of a considerable degree, and excoriations of the eyelid result.

The **treatment** consists in removal of the parasites and their ova. The difficulty attending this procedure is often great, so that it is frequently necessary to remove the cilia themselves. To re-

move the ova, their gelatinlike capsule must be softened by sweet oil or petrolatum. Solutions of sodium bicarbonate and boric acid are also useful. A weak mercurial ointment may be employed.

Distichiasis is an affection of the margins of the lids in which a double row of eyelashes is present. **Trichiasis** is the term applied to an abnormal position of the cilia. These conditions are nearly always combined, and may be congenital or acquired. The acquired forms are due in most cases to inflammatory diseases such as trachoma. They may also be due to burns and injuries of the lids. The constant irritation of the cornea induces vascularization of that structure in all cases of long duration. Often the misplacement of the hairs is associated with entropion. The common symptom in these conditions is the complaint of a foreign body, or "wild hairs," in the eye.

The **treatment** consists in epilation, destruction of the follicle, changing the position, excision, and transplantation. Epilation of the hairs can be easily performed with the aid of cilia forceps, but is unsatisfactory in that the hairs grow out in a very short time. Electrolysis is more satisfactory on account of the destruction that takes place, but is a very tedious process, and often painful. The injection of cocain into the follicle renders it more tolerable. In the practical application of the treatment it should be remembered that the needle should be attached to the negative pole and the positive pole should be placed against the temple. *Illaqueation* consists in withdrawing the misplaced cilia through an artificial opening in the lid by means of a noose. The elasticity of the lashes defeats this operation by allowing them to regain their abnormal position within a short period. The operative procedures devised for this annoying condition also aim to relieve the entropion which is so commonly associated with it, and most of these operations are described under entropion. The more simple operations consist in incision of the lid and excision of a wedge-shaped portion of the skin of the edge of the lid containing the cilia. The simple incision treatment consists in freeing the edge of the upper lid from the lower border of the tarsus along its entire length. In the excision method the lid is split near its conjunctival border, and a V-shaped portion of the skin containing the bulbs of the misdirected hairs is removed. The field of operation is rendered bloodless by some

form of entropion forceps, and after their removal hemorrhage is controlled by pressure over the supra-orbital notch and upon the edge of the lid. The success of this operation is assured if a piece of the integument containing very few hairs is taken from back of the ear, wrist, or arm, or mucous membrane from the lip, and grafted upon the raw surface of the open wound. As trichiasis is usually associated with entropion, a further description of the operation for its relief will be considered under that subject.

TUMORS OF THE EYELIDS

Epithelioma, or skin cancer, attacking the eyelids, is usually superficial or of the rodent ulcer type. The superficial variety is characterized by one or more grouped yellowish papules or patches of degenerative seborrhea. It begins after middle life. The lesions become excoriated and scales and crusts form, which are removed only to be followed by other crusts. The course of this form of disease is very slow, and years may elapse before ulceration takes place. When ulceration is present it is rounded in shape with well-defined pearly or rolled borders. It may be elevated or depressed, and the edges are indurated. Bleeding occurs upon the slightest injury, and a secretion of yellowish fluid is often present. The general health is unimpaired, and there is no lymphatic involvement or metastasis. Destruction of the growth in its early stage is indicated, and may be accomplished by the use of caustics, such as arsenic trioxid, caustic potash, or pyrogallic acid. Excision

Fig. 20.—Epithelioma of Lower Lid, Invading Upper Lid. (Author's case.)

may also be performed and skin grafts applied. These procedures, excepting skin-grafting, leave behind scars that may cause

FIG. 21.—RODENT ULCER OF LOWER LID BEFORE OPERATION. (Author's case.)

FIG. 21a.—RODENT ULCER OF LOWER LID AFTER SKIN-GRAFTING. (Author's case.)

considerable deformity. The application of the X-ray is probably the best form of treatment.

The **rodent ulcer** (Jacob's ulcer) form of epithelioma most often attacks the lower lid at its inner half. It begins as a hard

FIG. 22.—EPITHELIOMA OF EYELIDS. (Author's case.)

papule or nodule that ulcerates early in the course of the disease without the formation of any new tissue. It has a punched-out appearance and a slight roll-like border. The lymphatic glands behind the ear and in the post-cervical region are not involved until late in the affection. The disease usually occurs in the latter part of middle life, and shows a marked tendency to destroy tissue. It is chronic and is attended by very little cachexia.

The **treatment** is difficult on account of the small amount of tissue that may be removed. Excision of the edges serves to enlarge the ulcer, and there is seldom enough vitality to the skin to regenerate and fill up the excavated area. If seen very early, excision or other methods of removal may be employed. In later cases the X-ray offers the most hope of cure. The use of radium has been advised. The author has obtained good results from skin-grafting.

Syphilis of the eyelid may occur in any stage of the disease. Apart from recognition of the disease for the sake of the patient's general health, it is important to distinguish chancre from beginning cancer or sarcoma on account of the results of treatment upon the eyelids. *Chancre* in this situation causes enlargement and eversion of the lid, with the characteristic parchmentlike induration. It is most often located at the inner angle of the lids. There is enlargement of the post-cervical lymphatic glands, and the secondary eruptions upon the body may or may not be present. The difficulty in recognizing extragenital chancres arises from the fact that the ordinary description given applies only to the genital lesions, and it is obvious that they undergo more or less alteration in the various parts of the body according to the character of the structure in which they are found. The induration and the pseudo-membranous covering, however, are characteristic in all situations. In some cases the chancre appears as a superficial abrasion under which the parchmentlike infiltration may be detected.

The macules, papules, and pustules of syphilis may occur on the external surface of the eyelids as elsewhere. Upon the mucous membrane of the lids the papule becomes converted into the mucous patch.

The late lesions of syphilis, tubercles and gummata, may occasionally form upon the lids. The tubercular form is characterized by brownish-red or ham-colored, deep-seated papules or tubercles

usually arranged in the shape of an incomplete ring. Gummata begin as circumscribed infiltrations of the tissue underlying the skin, which increase in size, forming one or more flat, painless tumors. These break down and ulcerate without any true inflammatory reaction.

The **treatment** consists in the internal administration of mercury, or iodids, or both. Local treatment is unnecessary.

Lupus erythematosus, or lupus nonexedens, is a new growth involving the skin of the face, but sometimes extends to that of the eyelids. It is characterized by sharply marginated reddish patches covered by yellowish scales firmly adherent to the skin. As it exhausts its soil it leaves behind white atrophic cicatricial areas. The affection occurs most often in women, and is essentially a disease of middle life. It is extremely chronic, and runs an indefinite course.

The *treatment* includes applications of sulphur ointment, 1 dram (4.0) to the ounce (32.0), salicylic acid in collodion, 10 grains (0.6) to the ounce (30.0), tincture of iodin, the X-ray, and sometimes scarification. Lotio hydrargyri nigra is useful. Quinin internally is of value.

Lupus vulgaris, or lupus exedens, is the most important disease on account of the pronounced scarring produced by its extension to the eyelids. The disease is a form of dermal tuberculosis and belongs to the class of new growths of the skin. It is characterized by reddish or brownish patches made up of papules, nodules, and flat infiltrations. When the eyelids are involved the disease is usually diffused over the greater portion of the face. The yellowish or brownish flat papules are softer than the adjacent skin, and constitute the "apple-jelly" nodules first described by Mr. Jonathan Hutchinson. The papules develop into nodules, and these by aggregation form patches. After a varying period the lesions undergo retrograde changes, disappearing by absorption or ulceration. Scarring is a sequel in either event. The disease begins in youth and lasts indefinitely.

The **treatment** is local and general. The local treatment consists largely in curettement and cauterization, but the best results have been obtained by the use of the X-ray and the concentrated-light treatment after the method of Finsen. Internally, tonics, and milk-and-egg diet, combined with fresh air, are of great value.

Nevus, or angioma, or similar vascular tumors, are very frequent, and are congenital in origin. The port-wine birthmark of the face often involves the eyelids, and sometimes the abnormal blood-vessels form a pedunculated tumor. The color depends upon the predominance of either the venous or arterial vessels being brighter when the arteries are in excess.

The **treatment** in the sessile growths consists in removal, and this is best accomplished by electrolysis. This is a tedious procedure, and requires great care to avoid pain and subsequent scarring. In the pedunculated tumors excision may also be practiced, being careful to ligate the tributary vessels before removing the growth. Skin-grafting is frequently necessary to avoid the formation of cicatrices. Hot-water injections, after the method of Dr. John A. Wyeth, have been successful.

Dermoid cysts are occasionally found upon the lids at the outer angle of the orbit or the brow, and differ in no manner from dermoids in other portions of the body. Such a cyst presents itself as a soft, fluctuating tumor without inflammatory symptoms, and the usual contents—sebaceous matter, hair, etc.—may be demonstrated upon opening the cyst wall.

The **treatment** consists in removal of the entire cyst sac, or, in the event of its having already been opened, a sufficient portion of the cyst wall should be excised to prevent its refilling.

Verrucæ, or *warts*, and similar dermal hypertrophies, may occur upon the lids, the most frequent of which is the filiform wart, a slender, threadlike outgrowth. These may be conveniently removed by ligation, followed by cauterization of the base with glacial acetic acid. Electrolysis may be substituted for ligation.

Sarcoma, in rare instances, may occur as a primary growth upon the lids, and is characterized in the beginning by a pea- to hazelnut-sized or larger, firm, elastic tumor. It may or may not be pigmented. Nonpigmented sarcomas may be mistaken for chalazions, but the history and subsequent course serve to distinguish these affections. The **treatment** consists in early excision.

Xanthelasma (*Xanthoma; Vitiligoidea*) is a cutaneous new growth of the eyelids involving the connective tissue and characterized by circumscribed yellowish patches. It is said to result from fatty degeneration and also from displaced embryonal muscle fibers in the skin of the lids. The growths are flat and smooth,

and resemble chamois leather. It is most frequent in middle-aged women, particularly of the brunette type. Usually it is of no importance, as the lesion remains stationary after an indefinite period, but it may be associated with diabetes or jaundice.

FIG. 23.—XANTHELASMA. (Author's case.)

Treatment is usually unnecessary, except for cosmetic purposes. Excision, electrolysis, and cauterization may be employed to remove the growth, care being taken to avoid as far as possible any subsequent ectropion from cicatrization.

Dr. Thomas J. McCoy, of Los Angeles, in a personal communication to the author, explains how he has eradicated the affection from 14 different patients since 1896 by the local application of chromic acid in the following manner: The end of a round, moderately sharpened cotton applicator is dipped 2 mm. into deliquescent chromic acid, and dried over heat. The skin is stretched between the thumb and forefinger of the left hand, and with the other the point of the probe is inserted at right angles to the skin, and rotated until it has penetrated the epithelium. This is repeated 2 mm. apart until the whole affected area is covered. From 3 to 6 séances usually suffice. There may be slight smarting for a short while. Scarring does not occur.

Molluscum contagiosum, or **epithelial molluscum,** occasionally affects the eyelids, and is characterized by pinhead- to pea-sized, smooth, waxy-white or pinkish elevations containing a central depression or opening. It is a rare condition. The disease is feebly contagious. It is most common in children of the poorer classes. The importance of the affection arises from the fact that microscopically it resembles epithelioma. Cauterization with nitrate of silver or trichloracetic acid suffices in obstinate cases.

Leprosy is found in connection with the eyelids, a
in two forms, the tubercular and anesthetic. It is man
exaggeration of the normal folds of the skin and loss o
brows and eyelashes due to the infiltration of the lepr
Other symptoms, such as macules, tubercles, papules, ul
symblepharon, and gangrene are also present. Cicatricial
frequently occur as the result of repeated attacks of inf
tion. The prognosis is unfavorable and treatment is of ver
avail.

Elephantiasis, a chronic disease of the skin and unde
connective tissue manifested by hypertrophy and obstructi
the lymph channels, has also been observed in the eyelids, b
extremely rare. There is a congenital hypertrophy of the u
lid that resembles elephantiasis very closely.

**Neuroma, lipoma, adenoma, papilloma, lymphoma, co
cutaneum** (*cutaneous horns*), **fibroma**, and **myxoma** occur u
the lids, and should be differentiated from other growths in t
situation. Excision is indicated in each. Cysts frequently occ
on the lid borders and should be evacuated.

INJURIES OF THE EYELIDS

Wounds and **injuries** of the palpebral conjunctiva and lids are frequent as the result of various forms of traumatism. They require prompt treatment based upon aseptic surgical principles, with a view to prevent any open granulating surface, as the new connective tissue thus formed leads to troublesome deformities. Wounds should be carefully sutured under rigid antisepsis.

Ecchymosis is the technical name for the extravasation of the blood that takes place into the skin as the result of traumatism, and is a common occurrence in connection with the eyelids. In this situation it constitutes *black eye*, and gives rise to a play of colors beginning with red and gradually becoming darker, due to the disintegration of the blood and its pigment. Hemorrhage into the areolar tissue may occur from injury, or it may be a symptom of a constitutional disturbance, such as scurvy, purpura, etc.

The **treatment** varies according to the stage of the condition. Owing to the disfigurement it occasions, every means should be

always a possibility of infection through the newly formed channels. In occupations requiring forcible expiration, such as glass-blowing, playing of wind instruments, etc., a sudden forcible blowing may rupture a thin plate of the ethmoid bone.

Burns of the Eyelid.—These usually result from sudden contact with hot water, caustics, mineral acids, carbolic acid, cigar ashes, powder explosion, flame, molten metal, etc. Ordinary scalds and burns require the application of sweet oil, carbonate of soda, carron oil, boric-acid ointment, or the following salve:

℞	Phenolis	gr. xxx;	2.0
	Acidi borici, Bismuthi subnitratis,	āā ʒj;	4.0
	Unguenti zinci oxidi	℥ss;	16.0
	Petrolati	q.s. ad. ℥ij;	64.0

Misce. Sig.: Spread freely over closed lids, and bandage.

Indolent granulations on the site of a burn necessitate stimulation by balsam of Peru, silver nitrate, etc. The scar tissue that

FIG. 25.—SKIN-GRAFTING OF EYELIDS FOR CICATRICIAL DEFORMITIES FOLLOWING SEVERE BURNS.

forms gives rise to deformities such as *ectropion, entropion, symblepharon, and ankyloblepharon.* There is always great danger of the cornea being involved in such cases with irremediable damage to sight.

Treatment.—In the surgical treatment of symblepharon, good results are often obtained by implanting Thiersch epidermis grafts, after the method of Hotz, but even then, in many cases, it will be found that these cases are difficult to manage. In some cases the author has obtained gratifying results by inserting a glass conformer, modeled after the gold one used in the Mules' operation (*q. v.*). This serves the double purpose of preventing adhesions and permitting a view of the underlying conditions to be obtained through the glass.

AFFECTIONS OF THE TARSAL CARTILAGE

Tarsitis, or inflammation of the tarsal cartilage, is in most cases due to syphilis (*tarsitis syphilitica*), although the tarsal cartilage is frequently involved in diseases of the conjunctiva (amyloid degeneration, trachoma, etc.) and Meibomian glands. In the case of syphilitic tarsitis there is extensive swelling of the lid, which finally droops as a result of the increased weight caused by its enlargement. Distortion of the lid is the usual sequel. *Erysipelas of the lid* may cause an implication of the tarsal cartilage. The terms *tarsal tumor* and *tarsal cyst* have reference to *chalazion*, or *cyst* of the Meibomian glands, already described.

Tarsitis necroticans is a term applied by Mitvalski to the necrosis arising in the tarsal cartilage, as the result of an extension of an internal hordeolum. There may be considerable destruction of tissue in this variety.

The **treatment** of syphilitic tarsitis is obviously the exhibition of antisyphilitic remedies, preferably a mixed treatment, as the affection occurs as a tertiary symptom of the disease, and is of a gummatous character.

The most common *tumor* of the tarsal cartilage is *enchondroma.*

AFFECTIONS OF THE MUSCLES OF THE EYELIDS

The most important affections of the muscles in this situation are spasm and paralysis. The spasmodic conditions are *nictitation* and *blepharospasm*, and the palsied conditions are *ptosis* and *lagophthalmus.*

Nictitation consists in frequently repeated involuntary winking, and constitutes the so-called "life" of the eyelid. When exaggerated it results from a clonic spasm of the orbicularis muscle usually induced by excessive eye-strain. Neurotic conditions such as hysteria, chorea, neurasthenia, etc., may also intensify it. The instillation of eserin in the eye sometimes occasions this condition.

The **treatment** consists in the administration of remedies indicated by the underlying neurotic condition and a thorough examination of the refraction under atropin mydriasis.

Blepharospasm is a tonic or clonic contraction of the orbicularis palpebrarum. One or both eyes may be attacked, causing the patient to be blind during the period of the spasm. It is a reflex condition and attends irritation of the cornea and conjunctiva. Foreign bodies in these structures and phlyctenular disease are always accompanied by it, and it frequently accompanies fissures at the canthi. In some cases irritation of the facial or trifacial nerves may induce it and may be relieved by pressure over the styloid foramen or the supra-orbital notch respectively. Obscure cases are attributed to hysteria and central irritation of the nerves. A very persistent variety is the senile form, sometimes resisting all treatment.

The **treatment** in the majority of instances should be directed toward the local condition in the cornea and conjunctiva, as it is in these structures the cause usually resides. Fissures should be carefully looked for. In the senile form the constant electric current may be of value in some cases. Constitutional medication is often required, arsenic being of great value in some cases.

Ptosis, or blepharoptosis, is a condition in which the upper lid droops and hangs over the eyeball. It is always due to injury or disease involving the third cranial nerve, particularly in its distribution to the *levator palpebræ superioris*, but the conditions that give rise to such affections may be congenital or ac-

red. In some cases drooping of the lid is due to increased ight, as is seen in various inflammatory affections of the lid, l also to an increase in the adipose tissue of the lid. It may ɔ occur as a result of senile atrophy of the levator palpebræ erioris muscle, and in such instances is bilateral. These last-ntioned varieties are not generally considered as cases of true sis.

In congenital cases of ptosis, it has been observed that eleva-ı of the drooping lid occurs in abduction and adduction of the

'IG. 26.—PTOSIS IN A CASE (AUTHOR'S) OF OCULOMOTOR PARALYSIS.

ball and when the mouth is opened. Contraction of the pupil urs synchronously with these movements. Various explana-ıs have been advanced for these associated movements, none of ich, however, are satisfactory.

Ptosis may be of value as a localizing symptom in cerebral dis-e, and its relation to the brain should always be borne in mind. is of no value in locating cortical lesions, but its presence y serve to distinguish cortical lesions from those situated else-ere in the brain. As an example may be mentioned monolateral sis which, when unaccompanied by other focal symptoms, nts to the existence of a focus of injury or disease in the cortex ne. In disease of the pons, ptosis may occur on the same side

as the lesion independent of involvement of other points of distribution of the third cranial nerve. Its relation to crossed paralysis also cannot be ignored, as localization of a brain lesion may be greatly aided by its presence and character. In disease of the crus cerebri it is common to find the entire third cranial nerve palsied, but paralysis of the branch supplied to the levator palpebræ alone indicates a lesion of the cerebral peduncle.

Pseudo-ptosis is a rare form of the affection, which is not due to palsy of the third nerve, but seems to be a part of a unilateral vasomotor paresis. It is accompanied by elevation of temperature, redness, and edema of the paralyzed side, drooping of the lid with the retention of the ability to raise it, miosis, apparent shrinking of the eyeball, and an abnormal lacrymal, nasal, and salivary secretion of the same side. According to Nothnagel, the condition is associated with disease of the corpus striatum.

The paralytic forms of ptosis may be of central or peripheral origin. Those of central origin are due to the various forms of cerebral syphilis, brain tumor, or hemorrhage. The peripheral variety results from exposure to cold and wet when overheated, rheumatism, or syphilitic diseases of the third cranial nerve.

Treatment of Ptosis.—The treatment in all cases should be at first medicinal. Mercury and the iodides, salicylates, and tonics should be administered to their physiological limit. Bandaging of the eye should also be performed. Strychnin should also be given internally to its point of tolerance, and galvanism should be employed. If there is no response to internal treatment after a fair trial extending over eight to twelve months, some form of operative procedure may be performed, bearing in mind that the natural elasticity of the skin is likely to defeat the purpose of the operation.

If the lid droops so that vision is impaired, a small spring appliance made out of gold wire may be used, which presses gently into a fold of the skin with only strength enough to elevate the lid, but not enough to prevent its closing.

The most simple operation for this condition consists in excising a fold of the skin and sometimes the muscle in the long axis of the lid, and suturing the edges of the wound.

Birnbacher's operation necessitates the making of a curved incision with its convexity upward in the skin directly over the

upper edge of the tarsal cartilage. Three sutures carrying two needles each are introduced through the upper border of the tarsus. Three loops should then be formed in the cartilage. The needles of the central loop should be passed vertically upward under the skin, and should emerge in the eyebrow very close to each other. The lateral loops are introduced in a similar manner, but diverge from the central loop. The sutures should be adjusted and fastened over a small roll of lint or adhesive plaster to prevent their pulling through, and may be left in place for two or three weeks.

Everbusch's operation was especially devised for the relief of congenital ptosis, and aims to advance the insertion of the levator

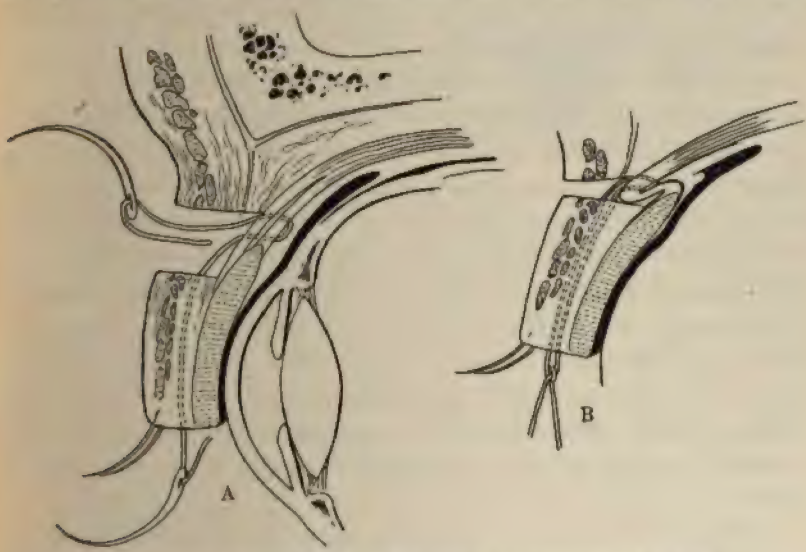


FIG. 27.—EVERBUSCH'S OPERATION (VERTICAL SECTION).
A Showing course of sutures B Completion of operation. Sutures tied.

palpebræ. The lid should be clamped and the skin divided the whole length of the lid parallel to its free margin midway between the brow and the ciliary margin. A free dissection is then made to expose the insertion of the levator, which is about 5 mm. below the upper margin of the tarsus. A suture carrying two needles is introduced into the muscle at its insertion so as to include about 2 mm. of its tendon. The needles are then carried downward between the orbicularis and tarsus to the ciliary mar-

gin, where they emerge at a distance of about 2 mm. from each other, the ends being fastened over glass beads. A nasal and a temporal suture are introduced in the same manner.

Freeland Fergus' operation is performed by making an incision 1 to $1\frac{1}{2}$ inch long over the orbital ridge. A portion of the occipito-frontalis muscle is dissected free and brought down between the tarsus and the skin to the margin of the lid, where it is fastened by means of sutures. The contraction of the muscle serves to elevate the lid.

Gillet de Grandmont's method of relieving congenital ptosis consists in the excision of a portion of the tarsal cartilage together with the removal of a portion of the tarso-orbital fascia and the levator muscle. The fascia and the tarsus remaining are then sutured by means of catgut.

Gruening's operation is a modification of Grandmont's method, and depends upon excision of a portion of the tarsal cartilage. An incision should be made through the skin and muscle of the upper lid parallel to its border and 3 mm. distant from it. The entire tarsal cartilage is exposed, and a portion measuring 2 mm. in height at each end and 6 mm. in the center is excised. A silk thread armed with 2 needles is then passed through the orbito-tarsal fascia and the free margin of the upper lid just above the eyelashes, where the free ends of the silk are tied. This serves to maintain the apposition of these two surfaces, and is greatly reënforced by the introduction of 3 such sutures. The skin wound is sutured by silk. The sutures should be removed at the end of four days.

Motais has devised an operation for ptosis in which a tongue-shaped flap is resected from the center of the tendon of the superior rectus and sutured to the fascia beneath the palpebral conjunctiva.

Mules' operation is more difficult. It requires clamping of the lid by means of an entropion clamp, after which the edge of the tarsus is grooved near its center behind the follicles of the cilia for about $\frac{1}{3}$ of an inch. The clamp is removed and the lid is drawn tense by means of forceps. A wire suture carrying two needles is then introduced. At each end of the groove a needle is passed upward for about half the width of the lid in the center of the tarsus, and is then thrust forward and outward through

the tarsus and skin, the wire being drawn through the incision made at the beginning of the operation. Ptosis needles, especially designed for this purpose, should be pushed deeply from the brow, separated by an interval of about 1/4 of an inch, undermining the skin of the eyebrow and lid to the incision, through which the wire has already passed. The wire is then removed from the needles first used and threaded upon the ptosis needles, which are then withdrawn through the openings in the skin of the eyebrow, where the ends of the wire are fastened after proper adjustment of the lid. A modification of Mules' operation is performed by N. B. Harman in which the

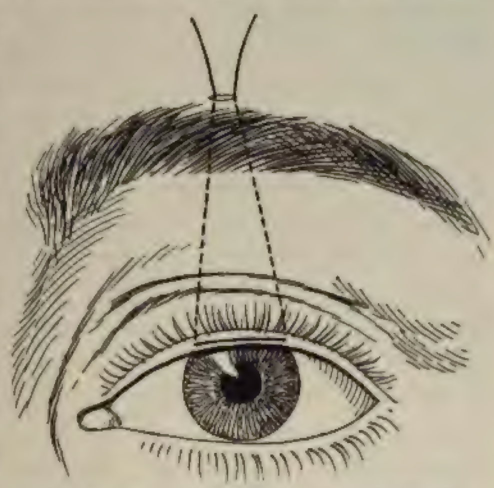


FIG. 28.—MULES' OPERATION FOR PTOSIS.

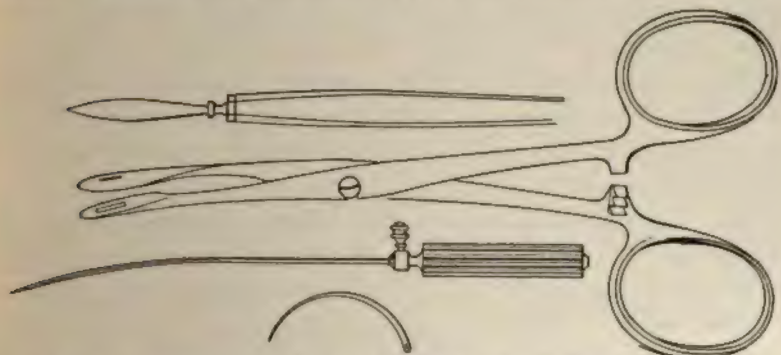


FIG. 29.—INSTRUMENTS FOR THE MULES' OPERATION FOR PTOSIS.

wire commonly employed is substituted by a fine chain similar to that frequently used for the suspension of eyeglasses, pendants, etc., known to the trade as " wire chain."

Pagenstecher's method consists in passing a suture in the form of a loop from the eyebrow close to the margin of the lid, where the ends are tied. It should then be tightened more and more

upon each succeeding day. The success attending this operation is not so great as has been claimed.

Panas' method consists in uniting a fold of the skin of the eyelid with the frontalis muscle on the forehead. For the accurate adjustment of the flap it is absolutely necessary that the skin of the forehead should be held firmly by an assistant throughout the entire operation. A horn spatula should be introduced beneath the lid and a horizontal incision made 1 inch in length extending to the periosteum directly over the orbital margin. A second incision should be made along the upper border of the eyebrow, and the tissue between these incisions is freed from its underlying attachments. A flap is dissected up on the lid from the first incision to the ciliary margin, avoiding the suspensory ligament of the lid. The flap is then drawn upward under the bridge of tissue and fastened to the upper margin of the high incision. Ectropion is avoided by the introduction of lateral sutures which include the conjunctiva and suspensory ligament, but exclude the skin. These are also secure to the upper incision.

Allport, of Chicago (*Journal of the American Medical Association*, 1903, p. 956), describes a modification of Panas' operation for ptosis, the object of which is to overcome the three principal objections urged against the latter procedure. The first objection is the failure of union between the tongue and bridge flap due to the unbroken skin surface of the former. This is readily overcome by denuding the tongue flap of its epithelium and thoroughly scarifying it before it is dissected from the underlying tissue. The second objection is the thick lumpy appearance of the bridge flap that persists indefinitely after the operation. This is to a large extent prevented by making the bridge flap as thin as possible and restricting its width to 5 or 6 mm. The third objection is the unsightly puckering that occurs at either angle of the lid. To remedy this, it is advised to cut off the corners of the side flaps (which are square in the original operation), and to denude them of the tissue underlying the true skin in order to make them as thin as possible. All the sutures are introduced through the tongue flap, as described by Panas, with the addition that two sutures are introduced on either side to unite the sides of the triangular flaps to the adjacent wound edges.

Wilder's operation consists in shortening the fascia that extends from the margin of the orbit to the tarsal cartilage by means of buried sutures. The aponeurosis of the levator muscle is shortened at the same time. The first step in this operation consists in making an incision 2 inches long in the eyebrow. To quote Wilder's directions: " A retractor being used to draw down the lower lip of the wound, the skin and muscle are separated from the fascia by careful dissection until the tarsus is brought into view. This is more easily accomplished if an assistant puts the lid on the stretch. Sutures of fine sterilized catgut or silk, armed at each end with a curved needle, are passed into the tarsus to secure a firm hold at a point near to the junction of the outer and middle third and a little distance from its convex edge. It is then drawn through, and with it several gathering stitches are taken in the tarso-orbital fascia, after which the needle is made to pass through the muscle and connective tissue of the upper lip of the wound. Another needle, on the same suture, follows a parallel course in the same manner, entering the tarsus about 3 mm. from the point of entrance of the first, then gathering the fascia into small folds and emerging in the tissue above, thus making a loop by which the lid may be drawn up. A second suture is passed in the same way, making a loop at the junction of the middle and inner third of the tarsus. The requisite elevation of the lid may be secured by drawing on the loop and tying the sutures which are to be buried in the wound."

Wolf's operations for congenital ptosis also have for their object the advancement of the levator palpebræ. His first method consists in incising the skin and severing the tendon, after which it is united by sutures of varying depths, according to the degree of shortening required. In the second method the operation is performed from the conjunctival surface.

Jessop's operation consists in the subcutaneous separation of the skin of the eyelid from the orbicularis muscle and the introduction of sutures extending from the margin of the eyelid to the brow. In beginning this operation the lid should be stretched and made firm by an entropion clamp (Snellen) or a bone spatula. A von Graefe's knife with its edge upward is introduced through the skin at the outer side of the lid and passed under the skin for its entire length. The knife is then carefully swept round

subcutaneously in order to separate the integument from the muscle and other underlying tissues. The knife may be reversed so that the skin is freed as far as the lid margin. A silk suture, threaded with a needle at either end, is then employed. One needle is introduced about 2 mm. from the ciliary margin at the junction of the outer third with the inner two thirds of the lid; it is passed upward beneath the skin, and emerges a trifle above the eyebrow. The remaining needle is introduced 2 mm. from the first, and pursues a parallel course. At the junction of the inner third and outer two thirds a similar suture is employed in the same manner. Traction is exerted upon the ends of the sutures until the desired elevation of the lid is acquired, after which they are tied over pieces of rubber tubing. The sutures are removed at the end of a week.

Hess' Operation.—The eyebrow is first shaved, after which a curvilinear incision is made in its whole length through the skin and subcutaneous tissue. The skin of the eyelid is then dissected free from the underlying tissue from the incision to near the ciliary margin along the whole length of the lid. Three silk sutures, each armed with 2 needles, are then passed from without inward through the skin only midway between the eyebrow and lid margin, and are brought out at the upper part of the space made by previous dissection. (According to Lawson, these sutures are of most value when introduced close to the lid margin.) The sutures should be introduced so that each form a loop about 5 mm. in length, and should be so arranged as to divide the length of the ciliary border equally between them. Traction upon the sutures from above causes the upper lid to become folded upon itself, resembling the normal fold. The needles are then introduced under the brow and emerge a few millimeters above it, where the free ends are tied over a roll of adhesive plaster, after having accurately gauged the amount of traction necessary. A continuous suture is used to unite the brow incision. The lid sutures are tightened from time to time, if necessary, and are usually left in from eight to ten days.

Komoto's Operation.—This operation, devised by Komoto, of Japan, is performed as follows, as described by the author himself (personal communication):

"After making two incisions, each of about 1 cm. in the lid,

partially dissect off each piece with scissors. Insert a separate thread with needles attached into each end. Then divide the tissues with scissors subcutaneously on each side in an upward direction until the eyebrow is reached. Now bring one end of the flap upward underneath the skin by pushing both needles

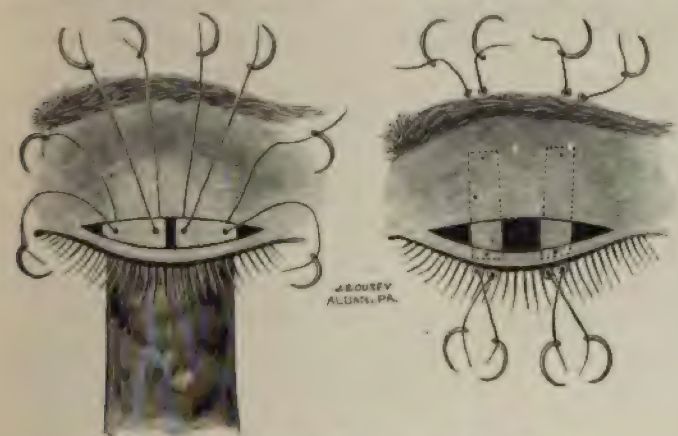


FIG. 30.—KOMOTO'S OPERATION FOR PTOSIS.

through the eyebrow and secure by a small glass pearl; the other end of the flap is brought toward the margins of the lid and secured with another small glass pearl. If it does not reach, take off a small piece from the lower end of the skin and attach again to the margin of the lid. Past experience has taught me to pull the one end slightly higher upward than the outer. As soon as the operation is finished the wound is closed. The result is usually excellent, and fails only if the strength of the frontal muscles is deficient. If a small dermoid cyst should appear in the underlying piece of skin (flap) it will disappear if incised and curetted; by extirpating the cyst, however, the result will be a very bad one, as an ectropion will follow."

The Author's Method.—The affected lid should be drawn down until its edge is directly opposite to that of the lower lid and the extent of the redundant fold of skin is ascertained. An incision is then made across the full width of the lid a few lines above the ciliary margin and parallel to it. A second incision is made parallel to this and at a sufficient distance from it to inclose the excess of tissue between them. This flap is then dissected

off by scissors and the skin above the upper incision is freed from its underlying attachments. The margins of the wound are approximated and sutured by interrupted sutures near the free margin of the lid. No scar follows, and ectropion is avoided by the undermining of the skin of the lid before suturing it to the lid border. The ultimate results are good and permanent.

FIG. 31.—AUTHOR'S OPERATION FOR PTOSIS.

In selecting an operation for the relief of ptosis the advantages of each operation should receive careful consideration, as no one method is adapted for all cases. Those operations that easily overcome ptosis often leave behind some cicatricial deformity equally disfiguring.

In ptosis, particularly in the paralytic variety, considerable benefit may be derived from the application of a strip of adhesive plaster to the forehead and eyelid to afford support to the latter during the day. It should always be combined with electricity and internal medication, as it is only an adjunct to the treatment.

Lagophthalmos, or palsy of the orbicularis palpebrarum, is manifested by a distinct inability to properly close the eyelids. It is common in connection with Bell's, or facial palsy, but may be present in conditions of the globe and orbit causing protrusion of the eyeball, as exophthalmic goiter, tumor of the orbit, staphyloma, etc. The condition may also result from narrowing of the lids as a consequence of injury, ulceration, or cicatrices. It is often present during unconsciousness on account of the absence of the lid closure reflex. The most marked cases are congenital in origin. The great danger in this affection is the probability of the occurrence of corneal ulceration from constant exposure of the eyeball.

The **treatment** should be directed toward any existing paralytic condition. Galvanism and strychnin should be freely employed, and a bandage should be applied to protect the eye. The

operative treatment consists in the performance of tarsorrhaphy. The operation of *tarsorrhaphy* was designed for the purpose of shortening the palpebral fissure when it is abnormally wide and consequently is applicable to conditions other than lagophthalmos. The point of approximation of the lids should be marked upon the skin at the external canthus. A horn spatula should be introduced beneath the upper lid, and a flap, corresponding to the

FIG. 32.—CONGENITAL LAGOPHTHALMOS.

marking, is made from the lids at the external commissure. This flap seldom needs to be more than 1 mm. in width and 4 mm. in length, and should contain all the hair follicles in this situation. Sutures are then introduced to approximate the edges of the wound. Sometimes the operation is performed at the inner canthus without removing the cilia in this location. Occasionally the protrusion of the eyeball is so great that suturing of the lids throughout the whole extent of their free margins is necessary.

CICATRICIAL DEFORMITIES OF THE LIDS

Under this heading are described those conditions of the eyelids that are caused by the contraction of newly formed scar tissue as the result of burns, injury, or similar destructive affections.

It includes entropion, ectropion, symblepharon, and ankyloblepharon.

Entropion consists in the inversion of the margin of the lid, and is usually attended by trichiasis. In most cases it results from scar formation in the conjunctiva and tarsal cartilage of the upper lid, but may be due to a spasmodic condition of the palpebral portion of the orbicularis, and in such cases the lower lid is involved. The last-mentioned variety of the condition is very common in aged persons, the senile changes in the adjacent tissues seeming to predispose somewhat to it. In entropion due to cicatricial tissue in the lid the underlying cause may be readily found to reside in some condition such as trachoma, burns, injuries, and improperly performed surgical operations. In the second variety, the prolonged use of an occlusive bandage, blepharospasm, and absence of the globe, are important causal factors. It is obvious that in all cases of entropion irritation of the cornea is constant, and injury is probable in the absence of prompt relief. The patient complains of the cilia scratching the cornea, and photophobia, pain, and lacrymation are present.

FIG. 33.—SENILE ENTROPION WITH TRICHIASIS.

Treatment of Entropion.—The treatment is largely operative, although temporary relief may be obtained by simple devices before resorting to surgical means. The application of collodion does good by its contraction when dry. Flexible collodion should not be used, as it defeats the purpose by reason of the oil it contains. The application of a strip of adhesive plaster has also been highly recommended. The operations devised for entropion also aim to relieve the trichiasis which is a constant accompaniment, particularly in the cases complicated with trachoma.

Burow's operation for entropion and also for contraction of the upper eyelids consists in splitting the lid from the inner to the outer canthus. The lid is everted over a horn spatula placed first upon the lid, and an incision made 3 mm. from and parallel with the free border of the lid. The incision, which is made with a Beer's knife or scissors, along a white line readily seen on the conjunctival surface of the lid, is through the cartilage only. The severing of the attachment between these structures allows the lid to assume a normal position by the elasticity of the superficial tissue. In cases unattended by any abnormality of the eyelashes this operation is curative. In the author's experience it is the best of the many operations devised for this deformity. A similar operation was performed in the latter part of the eighteenth century by Crampton of Dublin.

Berlin's operation is sometimes employed, and in it the first incision begins about 3 mm. above the ciliary margin, and extends across the whole length of the lid, dividing its entire thickness. The tarsus is exposed by a free dissection, and a portion of it and the underlying conjunctiva 2 mm. wide is excised. The wound is closed by sutures infroduced from the skin surface, and made to include all the divided structures.

Canthoplasty has also been performed, and is most useful in senile entropion. It consists in division of the external canthus. The conjunctiva at the apex of the wound is then sutured to the center of the skin incision, after which an upper and a lower suture is introduced to unite the conjunctiva to the upper and lower margins of the wound respectively.

Dianoux's operation consists in making an incision parallel to the free margin of the lid and about 4 mm. from it after an appropriate lid clamp has been applied. This incision should extend to the tarsal cartilage, but should not penetrate it. An intermarginal incision should then be made, splitting the lid into two portions, as in the Jaesche-Arlt operation. This second incision should be made deep enough to meet the first incision, thereby separating the ciliary portion of the lid in the form of a bridge. A third incision should then be made through the skin about 3 mm. above the first and parallel to it. The flap included between these incisions is dissected free, so that it is attached only at both ends. The lower margin of this flap is grasped by forceps in-

serted under the ciliary flap and drawn downward under it, to be fastened by sutures to the margin of the tarsus. The ciliary flap is then drawn upward and its upper margin fastened by sutures to the upper border of the highest incision. The objection to this operation lies in the fact that the fine hairs on the transplanted cutaneous surface may irritate the cornea to a very great degree.

Green's method consists in making an incision in the conjunctival surface of the lid parallel with and 2 mm. from the openings of the Meibomian glands. This incision should be made through the conjunctiva and tarsus extending the whole length of the lid. A strip of skin 2 mm. wide is excised from the lid at a distance of 1½ mm. above the ciliary margin, leaving the muscle intact. A curved needle carrying a suture is then introduced a little to the conjunctival side of the cilia and is brought out just within the wound made in the skin excision. It is drawn through and reintroduced in the wound at its upper margin, and passing deeply backward and upward in front of the tarsus it emerges from the skin about 1 cm. above its point of entrance. Three sutures inserted in this manner and tied usually suffice to relieve the condition. They should be removed in from twenty-four to thirty-six hours.

Ewing's operation for atrophic entropion of the lower eyelid consists essentially of a longitudinal incision through the tarsal conjunctiva and the tarsus parallel to and from 2 to 3 mm. distant from the line of the openings of the Meibomian glands. The lower lid is everted by a modified Desmarre's chalazion clamp, in which the blades are oval in shape. The spatula blade is set against the dermal surface of the lower lid near the ciliary margin, and moderate pressure is made downward and backward. This induces eversion of the lid, so that the conjunctival surface is engaged by the fenestrated blade at a distance of about 2½ mm. from the lid margin. The clamp should be fastened firmly and the incision should be made the full length of the lid parallel to its margin, being careful not to cut entirely through the lid. For a satisfactory result the incision should be carried through the tarsus and underlying fascia so as to expose the fibers of the orbicularis muscle throughout the entire length of the wound. After the incision of the tarsus has been complete, the partially detached marginal strip may be turned forward by means of

toothed forceps, or by inserting either a single thread near its center, or 2 or 3 threads, after which traction upon these threads will serve to draw the wound widely open and expose the muscle fibers. The sutures are usually 3 in number, and are passed through the conjunctival edge of the incision in the standing portion of the tarsus, and then through the marginal strip, being entered at the bottom of the wound between the muscle and the detached cartilage to emerge on the dermal surface in or a very little below the line of the cilia. The needle is then reentered through the skin in the same horizontal line, about 3 mm. distant from the first point of exit, and the suture is tied in the conjunctival incision. Any portion of the orbicularis muscle that may remain exposed is covered by the insertion of intermediate sutures connecting the conjunctival edge of the standing portion of the tarsus with the bottom of the wound. The sutures are removed in from three to five days.

Hotz's entropion operation is performed by making a curved incision through the skin of the lid corresponding to the upper border of the tarsus so that each end is about 2 mm. above each canthus. The edges of the incision are separated and a portion of the orbicularis muscle at the upper border of the tarsus is removed. Three or four sutures are then introduced, passing through the lower margin of the wound, the upper border of the tarsal cartilage, and the orbito-tarsal fascia, emerging from the skin at the upper margin of the wound. This has been further modified by an additional intermarginal incision and by excision of a portion of the skin of the lid.

The **Jaesche-Arlt method** is perhaps one of the best and most extensively used operations. The intermarginal portion of the lid should be divided for its whole length into two portions by an incision about 5 mm. in depth. The division should be such that the orbicularis muscle, skin, and hair follicles should be anterior to the incision and the tarsal cartilage and conjunctiva should be posterior to it. Another incision should now be made through the skin of the lid parallel to the first, but separated from it by an interval of from 5 to 7 mm. A third incision should begin at one end of the second incision, and should be carried upward in a curve, to terminate at the other end of the same incision. This forms a semilunar flap between the two incisions,

the height of which varies according to the effect desired, but it is usually 4 to 7 mm. The integument forming this flap should then be dissected away and the margins of the wound brought together by sutures.

The **Streatfeild-Snellen operation** consists in the removal of a wedge-shaped portion of the tarsus. The first incision is made 2 mm. above and parallel to the margin of the lid for its entire length. The tarsus is then carefully exposed by the excision of a strip of the orbicularis muscle. A triangular-shaped portion, with its apex directed toward the conjunctiva, is removed for its entire length. Sutures are then introduced to bring the edge of the tarsal wound together, but are unnecessary for the skin wound.

Von Graefe's operation is best adapted for entropion of the lower lid. In it a triangular-shaped piece of the skin is excised from the center of the lower lid with the base at the ciliary margin. The sides of the triangle are then sutured together.

Gaillard's Method.—Subcutaneous sutures may be of value at times and are introduced through the skin at the free margin of the lid and emerging from the skin $\frac{3}{4}$ of an inch below, where they are fastened over rolls of adhesive plaster. It is most applicable to senile entropion or inversion of the lower lid. The sutures are allowed to slough out, and the subsequent cicatrization brings about cure of the condition.

Excision of a horizontal strip of skin and orbicularis sufficient to overcome the entropion, and so that ectropion will not be produced, is also recommended in this condition.

It has been the experience of all ophthalmic surgeons that no one or two of these operations is applicable to all cases of this character, and that an operation must be extemporized for each individual case from the principles laid down in these several methods. In a number of cases under my observation a modification of the Burow and the Van Milligen operations, or their combination, yielded me most excellent results. The lid should be split for its entire length at the interciliary margin. A second incision posterior to it is made at the junction of the conjunctiva and the ciliary margin. The wedge-shaped portion of the lid between these incisions is excised, being careful to remove all displaced hair follicles in the resection. A strip of mucous mem-

brane from the lip or a portion of the upper layers of the skin behind the ear is grafted upon the wound. No sutures should be employed. Asepsis in every detail is necessary for a good result in this as in other ocular operations.

In all operations for entropion general anesthesia is absolutely necessary, and the cornea and globe of the eye should be protected by a lid-clamp or horn spatula.

Lagleyze's (Buenos Ayres) **operation,**[1] in which subcutaneous sutures are employed, is sometimes used with gratifying results. It may be performed under local anesthesia and requires only the use of a needle holder, a bistoury, a pair of scissors to cut the threads of the sutures, which are silk, and about 6 curved needles of 3 cm. length. After sterilizing the instruments and preparing the field of operation, he everts the lid in such a way that the limits of the superior border of the tarsal fibro-cartilage are easily presented in the field of operation. The needles are then introduced into the conjunctiva at the level of the tarsal superior border, and passed between the fibro-cartilage and the skin traversing the cellular tissue and orbicular muscle, and issuing from the free palpebral border at the level of the angle of implantation of the lashes. The needles should not be passed entirely through and should be placed equidistant, it being advisable to commence by placing the first in the center, in order that the surgeon may not be preoccupied by maintaining the eversion of the lid.

FIG. 34.—OPERATION FOR SENILE ENTROPION.

An incision is then made in the conjunctiva and tarsal cartilage, parallel to the border of the lid, approximately 3 mm. from the free border, from one extreme to the other if the entropion is complete to the depth of the needles. In partial entropion the incision must be made in proportion to the deformity, it being

[1] *Annals of Ophthalmology*, July, 1905, p. 473.

preferable to extend the incision beyond the limits of the entropion. The needles are then passed entirely through and traction is made in order to bring the deep loops of the threads in close opposition to the conjunctiva. Immediately after withdrawal of the needles, the lid returns to its former position. The ends of the threads which issue from the palpebral border must be separated, so as to obtain 5 loops if 6 needles have been employed. The ends corresponding to each loop should be tied over a small roll of gauze. The sutures are to be withdrawn at the end of a week.

Ectropion, or eversion of the lids, may be of two kinds—muscular and cicatricial.

Muscular ectropion affects most often the lower lid, and is common in old people, as the result of conjunctival edema and subsequent spasm of the orbicularis muscle. It may also be caused by paralysis of the palpebral portion of the orbicularis. Haab describes a condition of *spastic ectropion* found in young persons, due to an abnormal contraction of the orbicularis palpebræ which can be corrected by replacement and a suitable bandage.

Cicatricial ectropion is most frequently due to the scars following burns and wounds, but also results from the cicatrices of lupus vulgaris and from caries of the orbit.

The symptoms of ectropion are the result of the constant epiphora and exposure of the conjunctiva and are irritative in character. The term "blear-eye," so commonly applied to this condition by the laity, is particularly descriptive. The treatment is entirely operative.

Adams' operation for the relief of ectropion consists in excision of a wedge-shaped portion of the whole thickness of the lower lid, 5 to 10 mm. in width at the base of the external canthus. The edges of the remaining wound are then approximated and sutured.

Arlt's method consists in making a V-shaped incision outside of the borders of the scar extending from the inner and outer canthus down the cheek. The scar tissue is then almost completely undermined, and a portion at the apex of the V is shifted to the external canthus and sutured to the margin of the incision in this situation. The exposed surface on the cheek is covered by skin-grafts.

Wharton Jones' ectropion operation begins by making a V-shaped incision outside of the scar inducing the ectropion, after which the skin should be carefully freed from its underlying at-

FIG. 35.—CICATRICIAL ECTROPION.

tachments. The sides of the V are then united by sutures, beginning below, so that the incision is Y-shaped when the operation is completed.

Kuhnt's method is intended to produce shortening of the lid in order to overcome the eversion of the lid. The central third of the lower lid is split and a triangular portion, the base of which is formed by the margin of the lid, is removed from the posterior layer. Three or four sutures are then introduced to approximate the margins of the wound.

Argyll Robertson's operation is best adapted for those forms of ectropion secondary to chronic inflammatory conditions of the conjunctiva. It requires a piece of thin sheet lead (1 inch × ¼ inch), rounded at its extremities and shaped to the curvature of the eyeball, a waxed silk ligature, 15 inches in length, threaded to a curved needle at either end, and a piece of fine India-rubber tubing. The whole thickness of the lid should be perforated by

one of the needles, 1 line distant from the ciliary margin and ¼ of an inch to the outer side of the center of the lid. The needle is drawn through and passed directly downward over the conjunctival surface until it encounters the lower conjunctival fornix, through which it is pushed and continued downward under the skin of the cheek, emerging from it 1¼ inch below the edge of the lid. The other needle is introduced in like manner ¼ of an inch to the inner side of the center of the lid and brought out ¼ of an inch from the first, pursuing a course parallel to it. The lead is then passed under the loops that pass over the conjunctival surface of the lid, and the tubing is placed under the loop at the lid margin. The free ends of the ligature are drawn tight and tied over the lower end of the tube. The ligature is allowed to remain in place for about seven days.

Kenneth Scott's operation consists in division of the external canthus, followed by stretching of the margin of the lower eyelid outward and parallel to the border of the upper lid sufficient to restore the normal palpebræ fissure. The portion of the lid with its lashes extending over the external canthus should be removed. The margins of the two eyelids should then be approximated, after which two silver wires are introduced through them to hold them in position. The external canthus is restored by a continuous silk suture, which is allowed to remain for one week. The silver wire should be removed at the end of ten days.

Snellen's Sutures.—A silk ligature carrying a moderately curved needle at either end is required for this operation, which is begun by introducing one of these needles into the everted conjunctiva at its most prominent and exposed portion, and bringing it out through the skin about 2 cm. below the edge of the lower lid. The other needle is introduced in a similar manner 5 mm. from the first, and emerges on the cheek 1 cm. from it. Traction should then be exerted on the ligature and the lid pushed into proper position. The ends of the ligature are then tied over a roll of lint or adhesive plaster on the cheek. More than one suture of this character may be required, but none should be allowed to remain for more than four or five days.

Dieffenbach, Burow, Richet, Fricke, and others have devised operations for the restoration of the eyelid after the removal of contracting cicatrices, as in ectropion, all of which consist in

transplantation of a pedunculated flap of skin from adjacent areas. Their great differences lie in the variation in the shape of the respective flaps and in the location from which they are taken. Tarsorrhaphy (p. 79) and skin-grafting are also of great value. In all these operations, retaining sutures should be introduced from the lid margin and fastened in the brow to hold the lid in position until healing has been completed.

The Author's Ectropion Operation.—The author has had perfect success by the following method of operation: An intermarginal incision is made the entire length of the lid affected, about

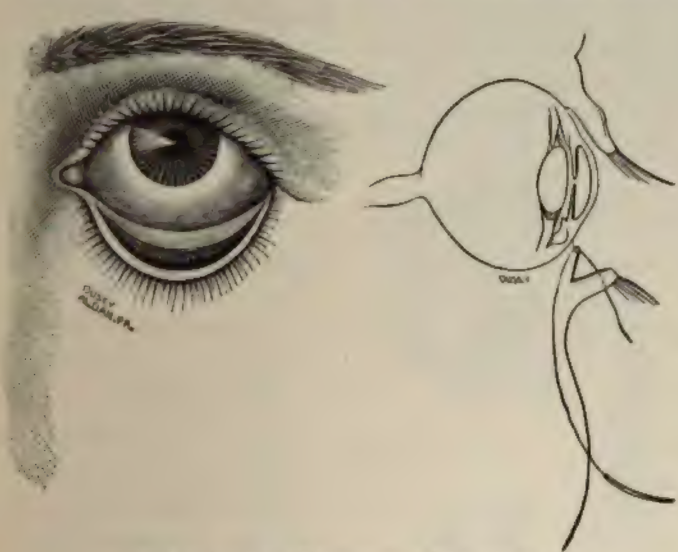


FIG. 36.—FOX ECTROPION OPERATION.

2 mm. from and parallel with the margin of the lid. The conjunctiva is dissected off and a V-shaped mass of the hypertrophied tissue excised the length of the lid, according to the degree of the ectropion and the amount of tissue present. The edge of the loose palpebral conjunctiva is then trimmed to the required width, after which the lid is placed in normal position and adjusted to the pared surface of the lid. A strong silk ligature, threaded with a long curved needle at each end, is then introduced by one of the needles at a point 6 or 8 mm. to one side of the center and 2 mm. below the insertion of the cilia, and passed through the whole substance of the lid. The needle (after having drawn the thread

through the lid a few inches) is passed through the fold of t[he] conjunctiva as it turns upon the globe, and, with a careful est[i]mate of direction, pressed downward through the tissues imme[-]diately beneath the skin of the cheek, emerging upon it $1\frac{1}{4}$ to 1[…] inch below the margin of the lower lid. The needle at the other end of the thread is entered about 3 mm. from the first insertion toward the angle of the eye, and carried through the lid, conjunctival fold, and cheek, parallel to the first. A second thread, with 2 needles, is used in the same way at an equal distance beyond the center of the lid on the other side. A bit of rubber tubing is placed under each loop before making tension. The lid is now drawn into proper position by careful tension upon the free ends of the ligature of the cheek, which are then tied over the rubber tubing already mentioned. Within twenty-four hours the lid will have swollen so that the pieces of rubber tubing can be withdrawn to keep the threads from cutting into the flesh, and within three days the threads may be severed and carefully extracted. No sheet lead is required, the eye need not be bandaged, nor is the occupation of the patient, as a rule, interrupted.

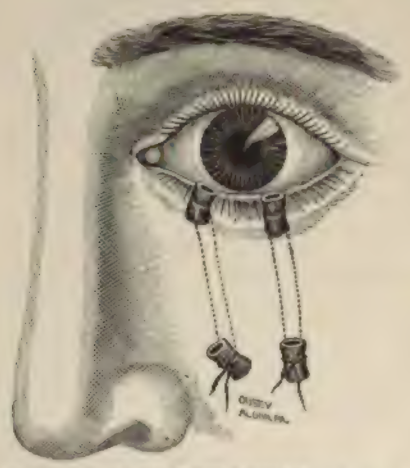
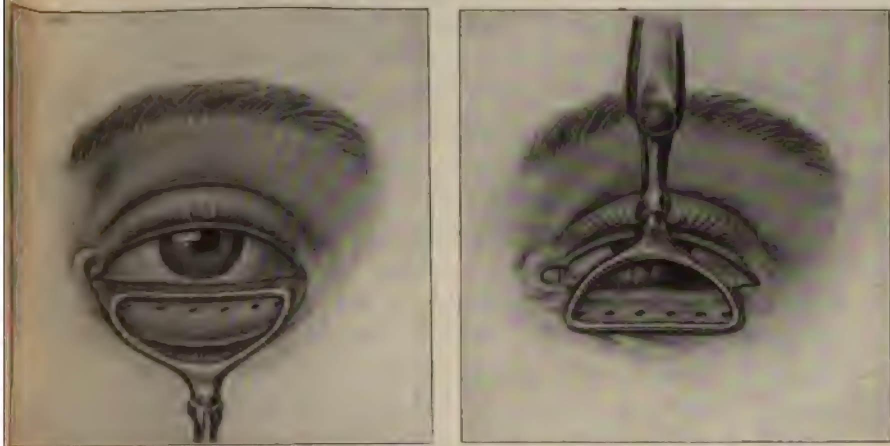


FIG. 37.—FOX'S ECTROPION OPERATION.

Ziegler's Operation.—Mild degrees of ectropion and entropion, whether spastic, senile, or paralytic in character, as well as cases of moderate cicatricial contraction, dimpling and distichiasis, may be relieved by the simple procedure of galvano-cautery puncture. Suture operations and flexible collodion are generally inefficient, while plastic operations frequently leave a disfiguring scar. The effects of galvano-cautery puncture are immediate, permanent, and show no scarring.

Two instruments are needed—a lid clamp with straight edge and a short, sharp, galvano-cautery point. The clamp is adjusted to the lid, the galvano-cautery point is applied to the sur-

face with considerable pressure, and then pushed through the cartilage and as quickly withdrawn. The punctures are located 4 mm. from the lid margin and separated from each other by an equal interval of 4 mm. They are made on the conjunctival



A B

FIG. 38.—ZIEGLER'S GALVANO-PUNCTURE OPERATION FOR ENTROPION AND ECTROPION.

A. Punctures for ectropion. B. Punctures for entropion.

surface for ectropion and on the skin surface for entropion. While the result is immediate in many cases, it may occasionally be necessary to repeat the puncture operation. There is but slight post-operative reaction, and the charred eschar of the cautery clears off in about a week.

Anesthesia may be secured by instilling cocain, by injecting cocain under the skin or conjunctiva, by freezing the skin in entropion, and by general anesthesia. If ether is used it should be removed before applying the hot cautery point or an explosion will ensue.

Symblepharon.—The term symblepharon refers to cicatricial union of the eyelids with the conjunctiva of the eyeball. It admits of several varieties in its extent, and may be acquired or congenital in character. In nearly all cases it is the result of burns and injuries of the conjunctiva and lids, particularly when improperly treated, but may be simulated by the scarring that follows the more serious conjunctival inflammation such as tra-

choma, diphtheritic conjunctivitis, gonorrheal ophthalmia, and xerosis. Strictly speaking, symblepharon is an abnormal condition of the conjunctiva, but for the sake of differentiating it from ankyloblepharon, which will be discussed later, it is described in this connection. Sometimes the cicatricial attachment between the lids and the cornea is designated as anterior symblepharon in contradistinction to posterior symblepharon, in which adhesions are formed that bind the under surface of the eyeball at the fornix, leaving the margin of the lid free. The restriction of the ocular movements induced by these bands impairs vision in addition to the deformity they produce.

Treatment of Symblepharon.—The treatment is prophylactic and curative. Wounds and injuries of the palpebral conjunctiva and lids are frequent as the result of various forms of traumatism. They require prompt treatment based upon aseptic surgical principles, with a view to prevent the presence of any open granulating surface, as the new connective tissue thus formed leads to troublesome deformities. The presence of open wounds of the conjunctiva should be prevented when possible by prompt suturing immediately after such accidents. When already in the granulating stage, the opposing lid surface should be separated from the wound repeatedly at short intervals to prevent union of the bulbar and palpebral conjunctiva. The application of petrolatum containing iodoform or boric acid acts very admirably in such cases. Simple bands of adhesions may be severed by one or two ligatures, according to their breadth, but in extensive involvement more complicated operative procedures are necessary. Thiersch's grafts are often implanted with gratifying results. A glass conformer is frequently employed by the author (see "Burns of Eyelid").

Harlan's operation is employed extensively in symblepharon of the lower lid, and has for its object the substitution of a skin surface for the scar tissue formed on the inner conjunctival surface. The whole thickness of the lid should be incised for its entire length along the lower margin of the orbit. A second incision is then made below this in order to form a pedunculated skin flap. After being carefully dissected from all its attachments, except the pedicle, it is turned up through the first incision in the lid and sutured to its under surface, the cicatricial bands having

been previously severed. The bare surface remaining upon the cheek is covered by a sliding flap taken from its outer extremity.

Teale's operation consists in making an incision through the attachment of the cicatrix (if it encroaches upon the cornea) corresponding to the corneal margin and dissecting the lid off from the eyeball as far as the fornix. Two flaps are dissected from the bulbar conjunctiva on either side of the cornea, one of which is made to cover the raw surface of the inside of the lid and the other is made to cover the wound on the eyeball. Sutures are then introduced to hold the flaps in position. The formation of a bridgelike conjunctival flap above the cornea and bringing it down to cover the raw bulbar surface has also been suggested by Teale.

Symblepharon may also be relieved in moderate cases by dissecting the conjunctiva from the cornea and turning it down so as to form the inner surface of the lid, to which it is fastened by sutures.

Transplantation of the conjunctiva from the eyes of animals and the mucous membrane from other portions of the patient has been employed with success.

Ankyloblepharon.—A condition in which adhesions form between the edges of the eyelids. It is due to union of these margins as the result of burns or other granulating surfaces. Symblepharon is frequently associated with it. Blepharophimosis is also applied to the condition of ankyloblepharon, but refers rather to the abnormal narrowing of the palpebral fissure. Usually this is about 26 mm. long and 1 cm. high, any departure from which is abnormal. A congenital narrowing of this fissure is sometimes observed.

The **treatment** is always surgical and requires separation of the lids, after which the bare surfaces should be covered with skin or mucous membrane. The operation of canthoplasty, in which the lids are separated from each other at either or both angles and the opposing edges of each lid are sutured together, is well adapted for this condition.

CONGENITAL MALFORMATIONS OF THE EYELIDS

The various deformities already described, such as ptosis, symblepharon, ankyloblepharon, blepharophimosis, and lagophthalmos, may be of congenital origin, and are probably the most frequent of these conditions. The less common malformations are complete absence (*ablepharia totalis*), partial development (*ablepharia partialis*), absence of sufficient covering of the lids, cryptophthalmus (in which the orbital integument is prolonged and covers a partially developed eyeball), coloboma, or fissure of the lid, and epicanthus, in which there is an abnormal crescentic fold of skin at the inner canthus.

The following case of *ablepharia partialis* reported by the author is of interest: The patient was a male child five months old. Examination revealed an entire absence of both eyebrows, although the orbital ridges were fully formed. The skin was

FIG. 39.—ABLEPHARIA PARTIALIS OF UPPER EYELIDS. (Author's case.)

continuous from the forehead over the ridges and in place of the normal eyelids it was prolonged into two pointed flaps (one over each eye), the apices of which were adherent to the cornea and conjunctiva—a condition which is not unlike symblepharon. The condition was best shown by the child looking downward. Upon looking upward, the skin fold was wrinkled

s the normal lid would be. In one lid a vestige of cartilage could e detected by palpation. Presumably there was no lacrymal land, as crying produced no enlargement of these skin folds as bserved in some cases. There were no lacrymal canals and the yeballs were in a condition of xerosis for want of secretion. 'he corneæ presented the appearance of maculæ, such as follow phthalmia neonatorum, but careful examination showed the true ondition. In one eye there was a partial area of clear cornea ear the lower border. The child seemed to have perception of ght.

FIG. 40.—LINE OF INCISION. OPERATION FOR EPICANTHUS. (Wicherkiewicz.)

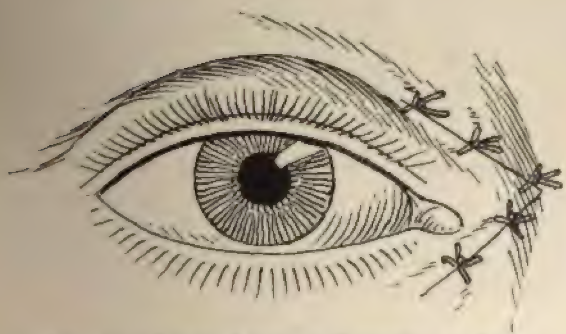


FIG. 41.—SAME, SHOWING SUTURES IN SITU.

Epicanthus is rather frequent, particularly in the Chinese, and equires transposition of the canthal ligaments together with sub-

sequent suturing of the wound edges on each lid. The grafting of skin or mucous membrane in this situation (canthoplasty) is often necessary.

Blepharoplastic Operations.—Such operations are required to relieve various cicatricial deformities and for the restoration of the eyelids after severe injuries resulting in their destruction. The individual operations for these conditions have been de-

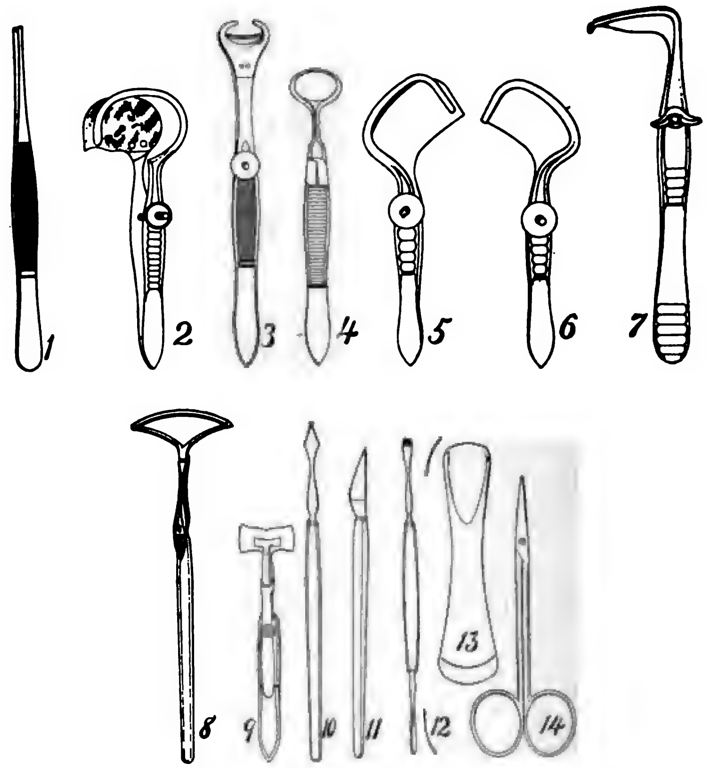


FIG. 42.—INSTRUMENTS FOR OPERATIONS UPON THE EYELIDS.

(1) Fixation forceps. (2) Knapp's entropion forceps. (3) Windler's lid-forceps. (4) Desmarre's entropion forceps. (5 and 6) Snellen's entropion forceps, right and left. (7) Lid-forceps (Vienna model). (8) Levis' lid-clamp. (9) Chibret's entropion forceps. (10) Straight keratome. (11) Sichel's knife. (12) Daviel's spoon and corrugated spatula. (13) Jaeger's horn spatula. (14) Straight scissors.

scribed elsewhere, but the principles underlying them will be considered under this heading. A general anesthetic is required in all these operations, and the field of operation should be rendered as aseptic as is compatible with the vitality of the tissues. The

cornea and the globe of the eye should be protected by some form of lid clamp or horn spatula when the presence of these instruments does not interfere with the operation. All scar tissue should be carefully dissected away and hemorrhage promptly controlled. Sutures should always be introduced in such a manner that the ordinary tension incident to opening and closing of the eye will not cause them to tear out. In the grafting of skin after the method of Thiersch, or of conjunctiva or other mucous membrane, all hemorrhage from the raw surface to be grafted should have completely ceased. The grafts should be of the same size as the area upon which they are placed, and require no suturing. Dressings should be applied that will keep the temperature of the area operated upon above that of adjacent structures. Sutures, applications, dressings, etc., should be prepared in conformity with the generally accepted aseptic principles.

CHAPTER V

DISEASES OF THE LACRYMAL APPARATUS

AFFECTIONS OF THE LACRYMAL GLAND

Dacryoadenitis.—An inflammation of the lacrymal gland.

This condition is of rare occurrence, and is commonly secondary to other conditions. It may be acute or chronic, suppurative or nonsuppurative. Extension from neighboring tissues, cold, compression, traumatism, syphilis, and acute infectious diseases may be mentioned as causes.

It usually assumes a chronic form, giving rise to redness and swelling of the upper lid, and injection of the conjunctiva. It is often associated with certain fevers, with mumps, syphilis, gonorrhea, rheumatism, and septic absorption. Acute inflammation often goes on to suppuration, attended with enormous swelling of the lids and adjacent tissues. The chronic form is generally painless, and the part is not sensitive to touch, while the acute type may be exceedingly painful. In the chronic form a firm tumor may easily be felt on palpation at the upper and outer margin of the orbit.

Treatment.—The usual antiphlogistic remedies should be tried. In the early stages of the acute form the application of cold compresses may be effective. Should suppuration be inevitable, thorough evacuation of pus by a free incision in the lacrymal gland, through the upper lid should be effected at the very first evidences of fluctuation. The wound should, of course, be treated under antiseptic precautions. The danger of an obstinate fistula should also be borne in mind. The chronic form, or hypertrophy of the gland, may be treated by the local application of tincture of iodin. The integument over the part should be kept irritated, if the treatment is to be effective. Iodides should be administered internally, in the hope of causing absorption of the tumor

mass. In chronic hypertrophy, its excision may have to be performed. Suitable remedies to combat any constitutional disease should be employed. If the condition is due to syphilis, inunctions of mercury and the usual antisyphilitic treatment are indicated.

Atrophy and **hypertrophy** of the lacrymal gland are among the very rare conditions to which that structure is liable. Atrophy is nearly always associated with *xerosis* of the conjunctiva, and is also believed to be a sequel to destruction of the lacrymal sac. Hypertrophy of the gland is the result of repeated inflammatory attacks, or it may be congenital. It is characterized by a firm, elastic, and nodulated enlargement. The increase in size is very slow and may lead to displacement of the globe or limitation of its movements. It is most frequent in children, and when very large should be removed.

Syphilis of the lacrymal gland is very infrequent and is characterized by a painless and noninflammatory enlargement of the gland. It may be mistaken for hypertrophy or some morbid growth of this structure. In every case of enlargement of the gland mercury and the iodides should be given a fair trial before resorting to surgical measures.

Tumors of the lacrymal gland are of uncommon occurrence, but deserve passing mention. The structure of the gland seems to predispose to adenoid growths, as these are most frequent.

Epithelioma, osteochondroma, lymphoma, sarcoma, tubercle, myxoma, hydatids, and *chloroma* have been reported and their presence has necessitated removal of the tumor, and sometimes the entire gland.

Dacryops in reality is a retention cyst of the lacrymal gland, and may be congenital, or it may arise in the manner just described. It occurs as a semitransparent swelling of a bluish-white color, and elastic in character. Fluctuation is easily detected. There is bulging of the palpebral conjunctiva of the upper lid, which is unduly prominent. The swelling is increased by anything that tends to increase the function of the gland. The occlusion of the canals is not always complete, so that a few drops of fluid may be expressed. Thirty-three reported cases have been tabulated by zur Nedden (1903). The treatment of dacryops aims at the restoration of the communication between the gland

and the conjunctival *cul-de-sac*. Incision of the cyst wall will bring about temporary relief, but requires constant attention. A ligature may be thrown around a portion of the gland from the conjunctival surface of the lid toward which it is allowed to ulcerate through, thereby establishing a fistula.

Injury of the lacrymal gland may result in displacement or fistula. Displacement of the lacrymal gland may also occur spontaneously, and in either case appears as a soft, movable tumor under the upper lid. In some cases interference is contraindicated, but usually efforts should be made toward reposition. As a last resort, the gland may be excised. Fistula usually results from injury, but may arise from the rupturing of an abscess. Cauterization may be employed in order to effect its closure, or a plastic operation may be performed. A better plan, however, is to introduce a suture into the gland from the conjunctival surface of the lid, causing it to emerge on the same surface, after which the ends are tied. As the suture ulcerates through the gland a new fistulous tract is formed which opens into the conjunctival fornix and affords free drainage. The original fistula then closes of its own accord, or after very little treatment.

AFFECTIONS OF THE LACRYMAL PUNCTA AND CANALICULI

In most anomalous conditions of these portions of the lacrymal apparatus it is the lower punctum and its canaliculus that are at fault, and to obtain a satisfactory conception of these affections one must recall the fact that normally the lower punctum is directed backward and upward toward the eyeball. The occurrence of eversion causes it to be directed forward and outward from the depression at the inner canthus in which the lacrymal secretion accumulates. As a result the tears do not find their natural channel of drainage and flow over the cheek, constituting epiphora.

It is customary to consider affections of the puncta and canaliculi as being congenital or acquired in character.

The principal congenital conditions consist of an excess or absence of the puncta or canaliculi. The presence of more than one punctum or canaliculus is seldom of any disadvantage, but may induce considerable embarrassment in introducing any in-

trument if their presence were unknown to the operator. The bsence of these openings is more serious, as epiphora is constant ntil a free communication is made with the nasal duct. The naking of an opening is indicated in these cases.

Acquired affections include displacement and obstruction. Displacement of the puncta and canaliculi may arise from any icatricial contraction of the conjunctiva or eyelids and from par-

Fig. 43.—The Lacrymal Apparatus.

alytic conditions of the eyelids. Obstruction may be brought ibout by the presence in the punctum or canaliculus of an eyelash, oreign body, leptothrix accumulation, polypi, calcareous concreions, etc., or by inflammatory thickening. Blenorrhea of the canaliculi may occur without involvement of the lacrymal sac.

Treatment.—The removal of any foreign body and the restoration of the condition of the conjunctiva and eyelids to normal

should be considered first in the treatment. If the condition still persists, relief may be afforded by splitting open the lower canaliculus with Weber's probe-pointed knife in a manner to be described in detail later. In one case, due to congenital absence of the punctum, in the author's experience, it was necessary to open the inferior duct and make an artificial punctum.

The connection between the nasal passage and the eye afforded by the nasal duct predisposes it to inflammatory conditions by

FIG. 44.—NASAL DUCT, OPENING INTO NASAL CAVITIES.

extension of like affections from the nasal or ocular mucous membrane, so that it is inflamed to a greater or less extent in all affections of these adjacent structures. As a result of the congestion and thickening of the mucous membrane, the caliber of the duct is lessened sometimes to a considerable degree, so that the tears are obstructed and flow over the lower lid and down the cheek, constituting the symptom known as:

Epiphora (*Stillicidium lacrimarum*, watery eye).—The overflowing of the tears upon the cheek. The secretion of the tears should be continuous, and their drainage into the nose such as to allow but a very small quantity to remain in the conjunctival sac. From this it may be easily seen that epiphora may result from excessive secretion or obstruction of the tears from displacement, from absence of the puncta, canaliculi, lacrymal sac, or nasal duct, or from some abnormality of the eyelids.

Excessive secretion of tears may result from emotional disturbances, inflammatory or irritative disorders of the conjunctiva, cornea, or lids, eye-strain, etc.

The affections of the lacrymal apparatus likely to induce it are: eversion of the punctum, such as occurs in ectropion of the lower lid; obstruction of the puncta and canaliculi as the result of foreign bodies, injuries, burns, or inflammatory exudates; and absence or obstruction of the lacrymal sac or nasal duct by calculi, foreign bodies, strictures, etc. According to Haab, an hereditary predisposition is the chief etiological factor.

Among the abnormalities of the lids that are accompanied by epiphora may be mentioned ectropion of the lower lid, symblepharon, etc. Ectropion may be due to cicatricial contraction of the lid, senile changes, or paralysis of the orbicularis muscle. The last condition, paralysis of the orbicularis, is most frequent as a part of a facial palsy, and is often the only prominent symptom of such a condition. Its importance arises from the fact that it is likely to be mistaken for some obstruction of the nasal duct

FIG. 45.—PUNCTUM DILATOR.

and improper treatment instituted. Overlooking the existence of a facial palsy in connection with epiphora, while not a grave error, is a very embarrassing mistake, as the condition persists after treatment directed toward the eye or its appendages.

Treatment.—The measures adopted for this condition take into consideration the various causes from which it may arise. The condition of the cornea and conjunctiva should be ascertained and appropriately treated. Not infrequently particles of dust or

foreign bodies may induce an excessive secretion of tears with their subsequent overflow upon the cheek, and in all cases a careful examination should be made to determine the presence of such foreign substances. An element of eye-strain being present in nearly every individual, the refraction should be examined, but the prescribing of correcting lenses should be left to the judgment of the attending ophthalmologist. In most cases correcting lenses should be worn, as they not only lessen the accommodative effort and subsequent congestion, but are protective in that they prevent to a large extent the contact of irritants with the conjunctiva and cornea.

Deformities, displacements, and obstruction of the lacrymal apparatus require surgical interference for their relief. Deformities and displacements always necessitate some operation by which the opening of the punctum is placed in its proper position and the canal from it to the lacrymal sac made patulous. This varies according to the character of the underlying structures.

Obstruction to the nasal duct is more common, and, to a certain extent, difficult to permanently relieve. Often relief may be afforded by dilating the duct with a fine-pointed probe.

The occurrence of a stricture or purulent inflammation in the nasal duct always requires more radical measures. (See Dacryocystitis.) The presence of these conditions in the duct necessitates first the slitting of the lacrymal canaliculus by means of a Weber knife, after which the duct is dilated to its greatest width by silver probes. A gold cannula should then be inserted, guided by a probe specially adapted for this purpose. This cannula should not be allowed to remain undisturbed indefinitely, but should be raised and lowered from time to time to prevent filling up of its interior and the formation of adhesions. Unless prepared to elevate the tube in a certain manner, the raising of it is not only painful, but extremely difficult to perform. It must be remembered that in cases in which the nasal duct has been rendered patulous by the introduction of a gold cannula, the margins of the canaliculus slit by the Weber knife show a tendency to unite over the mouth of the tube; but if the stricture is still present and the obstruction persists, this union occurs with less frequency. The mouth of the cannula should then be loosened before any attempt is made to raise it, and its shelf should be directly for-

ward so as not to wound the conjunctiva or eyeball. A probe, on the end of which is a hook resembling in every detail a crochet needle, is passed completely through the cannula and is raised, keeping in close contact with the cannula until the hook catches upon the lower edge of the tube, after which the hook and cannula are gently drawn upward.

The slitting of the canal and the passing of the knife downward, while apparently a simple operation, is, however, not entirely free from danger, since false passages are easily made, or the knife may become wedged in the bony wall and break. In cases where there are pronounced swelling and edema of the lids, it is better to use an antiphlogistic lotion for several days before operating.

In the whole range of ophthalmic surgery no class of cases gives more trouble and annoyance to the surgeon, and more discomfort to the patient. They are practically never cured; the least exposure to colds or draughts of air causes the tears to flow over the margins of the eyelids, and in many cases produces eczematous eruptions on the cheeks. The presence of pus in the lacrymal sac causes not only an inflammation of the nasal cavities, but also of the conjunctiva, and this condition leads to radical changes in the delicate tissues of the eyelids and Schneiderian membrane of the nose. Not only is the appearance of the eye repugnant, but the foul odor from the diseased bone in the nasal cavity is most offensive, and renders these unfortunate patients objects of sympathy.

As regards treatment in general, mild astringent washes do good in certain cases, as do also dilatation of the puncta or of the whole canal, and syringing, as first suggested by Anel in 1712; but these methods number a failure for every cure. The modern treatment, as practiced by the French and German ophthalmic surgeons, consists in the introduction of fine probes, which do not dilate the canal to any extent, while on the other hand many of the English surgeons dilate the canal to its full caliber. In this country ophthalmologists are divided in opinion as to which is preferable. The author's experience leads him to believe that passing the larger size produces the best results, and he immediately follows it by the introduction of a gold cannula.

AFFECTIONS OF THE LACRYMAL SAC AND N

Dacryocystitis.—The chief affection that is lial
the lining membrane of the lacrymal sac and nasal du
mation, acute or chronic in character, known as *da*
also known as blennorrhea, swelling of the lacrym
according to the nature of the inflammatory attack.

In the acute form, in addition to the edema, swellir
pain, tenderness, etc., there is epiphora due to the inf
swelling within the lacrymal sac and nasal duct, and th
tion to the tears induced by it. The distention of the w
sac by secretions often forms a round globular mass call
cele, which has been found to contain the xerosis bacillus,
in pure culture (Fage).

Acute catarrhal dacryocystitis is rarely a primary a
It usually follows upon a chronic inflammatory condi
the mucous membrane whereby strictures are formed
tears are obstructed in their passage and retained, und
pathologic changes. The secretions become infected by
organisms present in the conjunctiva or in the nasal passag
is possible to demonstrate the presence of various forms c
nitis in nearly all these cases. Diseases such as smal
measles, scarlet fever, syphilis, etc., are not uncommonly fol
by lacrymal disorders on account of the frequency with whi
upper air passages are involved during their course. Nas
mors, growths of the antrum of Highmore, actinomycosis, i
and congenital asymmetry of the face deserve mention, as th
occasionally encountered as causes. While the inflammat
still confined to the catarrhal stage, the chief symptom is *epi*

The affection usually becomes phlegmonous in natur
suppuration occurs early in its course. Fever and chills
the onset of suppuration, transforming the condition into
suppurative dacryocystitis. The lids and side of the nos
become red and tender to touch, and an erysipelatous sw
soon makes its appearance. The cellular tissue overlying t
and duct often becomes affected coincidently, and the res
abscess points near the tendo-oculi. If prompt and appro
treatment is not instituted in this stage of the affection, tl
scess ruptures and a fistula results. This is easily detected

upon the left eye, presses the thumb of the right hand over the cheek bone and just along the lower edge of the eyelid, which by this action is drawn slightly downward and outward. The bulbous point of the Weber knife is inserted into the punctum, and the handle is dropped below the horizontal plane of the eyelid.

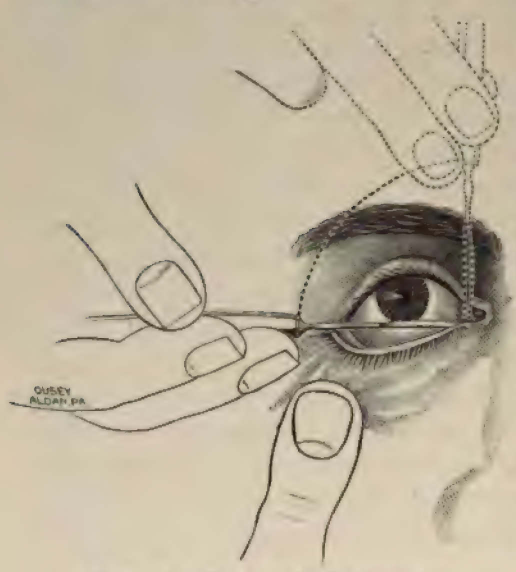


FIG. 46.—BOWMAN'S OPERATION.

With the cutting edge of the blade inclined toward the eyeball, the knife is pushed toward the nose, and, when the point has touched the nasal bone, the handle is raised to the vertical position; the cutting edge is rotated forward and is pushed firmly, yet gently, into the canal, burying the blade well up to the handle; this is done without difficulty and without giving much pain to the patient. The knife is withdrawn and by gentle pressure the bleeding is stopped in a few minutes. A silver probe of large size, which passes well down into the canal, is now inserted, and is allowed to remain for several minutes; it is then withdrawn and a silver cannula placed in permanent position. The tube is allowed to remain in the canal for several days, when it must be removed, cleansed, and returned to its place. This may be repeated at intervals of several days, until the secretions have disappeared and a free opening is obtained. When a cannula is to be worn permanently, it should be made of gold. The longer the cannula or style is allowed to remain in the duct, the better the result will be.

If pointing has occurred, Petit's method of operation should be followed—namely, incising the abscess and passing the knife into the canal below the lacrymal sac.

When we meet a patient who has had more than one operation performed, and cicatricial tissue has formed along the mouth of

the sac, it is impossible to use a Weber knife. For this purpose nothing approaches a *Stilling* blade. The method of inserting and passing the knife downward is the same. The incision is followed by the insertion of a large-sized probe and cannula.

A very simple method of proving whether the canal is open is to have the patient shut his lips and close his nostrils with his thumb and finger, and then try to force the air through the lacrymal cannula.

The frequent raising and lowering of the tube, as described in the treatment of epiphora, is applicable here.

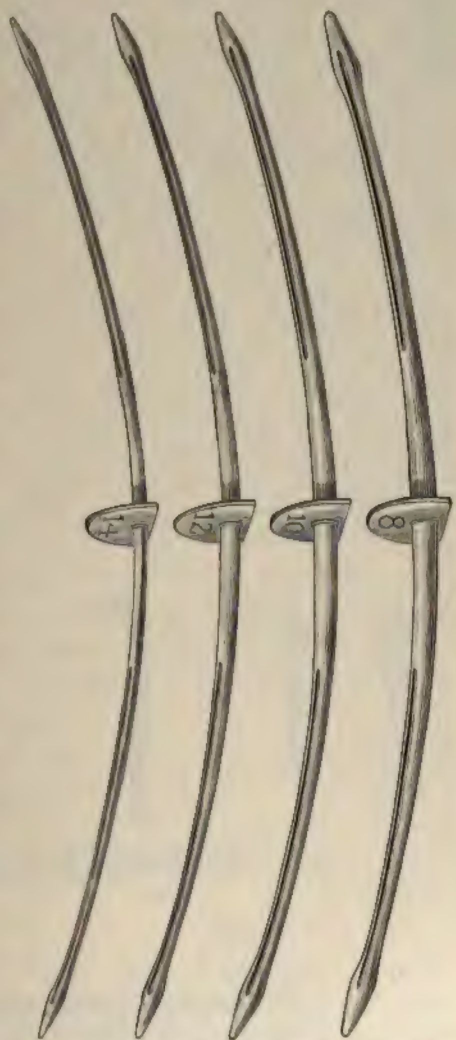
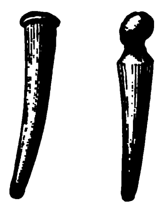


FIG. 47.—SILVER GROOVED LACRYMAL PROBES. (English Standard Wire Gauge.)

The introduction of lacrymal probes into the nasal duct at regular intervals is practiced extensively. It is usual to either split the punctum and canaliculus or dilate the punctum by Weber's conical sound before attempting to pass the probes. One of the smaller sizes, preferably a No. 3, should be selected to start with. It is introduced in a manner similar to that of the knife in the foregoing operation, following the direction of the canaliculus. The surgeon is able to work more conveniently by standing behind the patient. The probe should be passed to the inner wall of the sac, after which it is raised so that

the lower end enters the nasal duct. That the probe has i the right channel will be indicated by the complete abs wrinkling or creases around the probe, as there should be ı tion upon the soft structure if the probe has pursued the course. Should the probe encounter bonelike resistance afte been raised, the opening of the duct has been missed, and tl danger of producing false passage with more or less celluliti: attempt is made to force the probe farther. The inflamm swelling offers a more yielding resistance, and is overcome b} but gentle pressure. The probe having entered the duct, it sl be pushed onward until it emerges in the inferior meatus o: nose. The probes should be allowed to remain for fiftee twenty minutes. They are gradually increased until one of \ large caliber is employed. In chronic cases it requires sev days before the largest sized probe is employed. In acute ca the sizes are increased rapidly at the first sitting until the d is dilated to its full width, after which a leaden style is introduce

Rapid dilatation by means of an especially constructed instn ment, not unlike that of Weber's conical sound, but elbowed an



a b

FIG. 48.—*a*, DUPUYTREN'S CANNULA; *b*, WATHEU'S CANNULA.

FIG. 49.—FOX'S GOLD CANNULA.

FIG. 50.—GROOVED STYLE.

FIG. 51.—FOX'S GOLD CANNULA. LATEST MODEL.

mounted differently in order to afford more leverage, is in great favor among certain ophthalmic surgeons (Levis). The operation consists in dilating or slitting of the punctum and canaliculus, after which the conical probe is rapidly introduced and forcibly pushed into the nasal duct. There is always a sensation of crackling attendant upon the operation, which is attributed to carious bone; but an attempt to pass a probe of the size usually employed through the duct of a dried skull will be attended by

same phenomenon, showing that there is always some destruction of bone by the operation. The results reported from this operation in chronic lacrymal inflammation seem most gratifying and deserve consideration. In acute cases the lead style is employed in addition to rapid dilatation.

J. W. Jervey has devised a method of treatment for strictures of the nasal duct that is worthy of description. He first instills adrenalin and cocain, and if it is impossible to pass through the canaliculus a No. 1 or No. 2 Bowman probe, it is incised for about 2 mm.; this failing, it is slit in the usual way. He then dilates the nasal duct by means of an instrument designed by himself, the principle of which is simply that of a wire bent double upon itself. When traction is made upon one free end, by turning the thumbscrew, the other being held firm, a buckling results which accomplishes dilatation. Syringing may be performed at the same time. The instrument is provided with a sliding collar, which can be pushed down to the punctum in those cases in which splitting is necessary, so preventing any possible rupture of the punctum or canaliculus while dilating the remainder of the canal.

Electrolysis of the nasal duct for the relief of strictures has also been employed with success. The only disadvantage of this operation is the great size of the cannula necessary for guiding the electrode, and it is questionable whether the dilating effect of this cannula is not of greater benefit than the effacement of the stricture by the electric current.

Irrigation of the lacrymal sac and nasal duct after dilatation has been accomplished is a most excellent method of treatment in

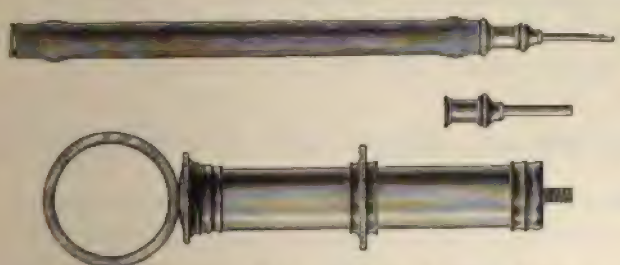


FIG. 52.—LACRYMAL SYRINGE WITH RUBBER TUBING.

that it not only antisepticizes the contents, but tends to restore the mucous membrane to a healthy condition. Anel's syringe is

usually employed with a cannula of a caliber sufficient to enter the punctum and canaliculus, without pain. The following solutions are used:

Lead acetate	1.00	per cent.
Nitrate of silver ... 2 to	5.00	"
Zinc sulphate	0.60	"
Protargol	10.00	"
Tannic acid	2.00	"
Bichlorid of mercury	0.02	"

Boric acid (saturated solution), and solutions of formaldehyde, and potassium permanganate.

In chronic conditions in which the secretion has accumulated in the lacrymal sac, constituting mucocele, it has been advised to express the contents by pressure and gentle manipulation. While this is a harmless procedure, it cannot be relied upon, and should not be preferred to more effective methods of treatment in view of the character of the sac contents.

In cases of abscess formation, and even in obstinate chronic dacryocystitis, some surgeons prefer to incise the anterior wall of the sac, curetting the interior and packing it with gauze. When the mucous membrane has regained its normal condition, the packing is removed, and the external wound allowed to close.

Extirpation of the sac is recommended as a last resort, but the difficulty encountered in performing this operation usually causes it to be changed into one of destruction by the use of caustic and the cautery.

In lacrymal stricture of the new-born it is the practice of J. M. Crawford to make use of pressure over the sac several times daily as an adjunct to other measures.

OPERATIONS FOR EXTIRPATION OF THE LACRYMAL SAC

Kuhnt's Method.—Extirpation of the lacrymal sac by Kuhnt's method consists, first, in making an incision through the skin and underlying structures until the bone is encountered for about 2.5 cm. over the anterior lacrymal crest, beginning about 4 mm. above the internal palpebral ligament and ending about 5 mm. below the commencement of the bony lacrymal duct. The palpe-

bral ligament is then separated close to its insertion by means of scissors. The capsule of the scar is then exposed by drawing the temporal flap to one side, and incised along the crest, thus bringing into view the shining anterior wall of the sac. Its inner wall is then separated from the periosteum by means of closed blunt-

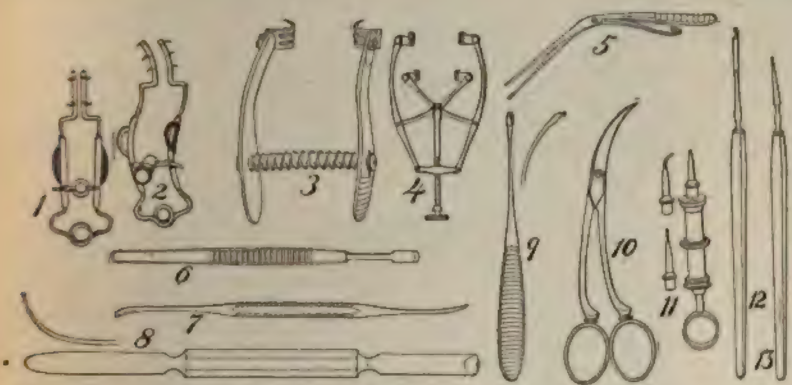


FIG. 52a.—INSTRUMENTS FOR EXTIRPATION OF LACRYMAL SAC.

Nos. 1, 2, 3 and 4. Müller's, Terriens', Axenfeld's and Sydney Stephenson's specula. 5. Galezowski's canaliculus dilator. 6. Rollet's lacrymal sac chisel. 7. Lang's lacrymal chisel. 8. Axenfeld's chisel. 9. Lacrymal scoop (Windler). 10. Daviel's scissors. 11. Anel's syringe. 12. Weber's canaliculus knife. 13. Stilling's canaliculus knife.

end scissors; the fundus and its adherent capsule is drawn forward and released from its attachments, and then the posterior wall is detached. The temporal flap is drawn forward and outward and the fundus of the sac is drawn inward and forward to facilitate freeing the anterior surface. The sac is then cut off close to the bony canal. In the absence of a stricture the mucous membrane is curetted. Drainage is established and two or three deep sutures are introduced, with the view of securing the palpebral ligament. In order to render the outlines of the sac distinct, C. R. Holmes injects into it a thick solution of starch, colored with iodin.

Vienna Method.—After an extended personal observation of this procedure, and a subsequent careful development of the technic, the author has successfully operated on 50 cases, in 10 of which he also excised the lower lobe of the lacrymal gland. Four of the cases were also subsequently operated on for cataract, with a successful termination. This method, as suggested by Fuchs,

cannot be better described than in the words of Dr. Jesse S. Wyler, of Cincinnati, who has prepared the following description at the author's request:

"This operation is always done under local anesthesia to avoid the local congestion and subsequent hemorrhage which obscures the field of operation when narcosis is induced. A one-per-cent solution of cocain in a Pravaz syringe to which one division of adrenalin has been added, is substituted in the following manner: The needle is inserted over the anterior lacrymal crest and directed upward and slightly inward subcutaneously, for about

FIG. 53.—DISSECTION OF THE REGION OF THE LACRYMAL SAC, SHOWING THE CIRCULATION.

The vein is the large blood-vessel on the left. The artery is on the right. The upper dotted line indicates the medial palpebral ligament. The lower dotted line shows the lower, inner outline of the orbit.

$\frac{1}{4}$ of an inch, and a few drops of the solution injected. The syringe is withdrawn and the needle is plunged to the bone just below the middle part of the canthal ligament and is directed downward, and the second third of the anesthetic mixture used, thus cocainizing the lower part of the sac. The same procedure follows above the ligament, the needle being directed slightly upward. The part is gently massaged for a couple of minutes, and then the operation may be started with impunity, for when properly administered nearly complete anesthesia exists.

"With an eye scalpel the first incision is made, cutting only ugh the skin, starting at a point just above the middle part of canthal ligament and running downward and slightly out-

FIG. 54.—INCISION FOR EXTIRPATION OF THE LACRYMAL SAC.

ypodermatic punctures. The skin is fixed with the thumb of the left hand. The cutting dge of the knife is held perpendicular to the bone. The incision is downward, slightly utward and somewhat curved.

FIG. 55.—RELATION OF STRUCTURES AFTER INCISION.

1. Internal canthal ligament. 2. Lacrymal sac. 3. Deep fascia.

ward over the crest. This bony promine
mark during the operation, and its loc
borne in mind. The edges of the skin
undermined and a Müller speculum ins
The floor of the opening is formed o
fascia, and this is easily divided with th
toothed thumb forceps and a light sciss
now taken up by the operator and the m
laris separated easily by blunt dissection,
line of the incision. During this perio
keeps the field of operation free from bl
forceps and a strip of gauze for tampo
now quite deep in many cases, but belo
can be plainly made out. Just over the
this fascia with the point of the scissors

FIG. 56.—RELATION OF STR
1. Division of canaliculi; 2, median palpebral ligament sev
in situ.

blade into the opening a straight incisio
the canthal ligament. This ligament
enlarge the field, but when done earlier th
hemorrhage from the large veins lying j
edges of the split fascia lies the pink sac

membrane is extirpated, the cavity washed with 1-1
solution and dried with gauze. The skin margins ar
by traction upon sharp hooks in each angle and 3
bring the edges together, good apposition being mo
for in such a case the scar is never visible. A piece of
vaselin is laid above, and a small roll of iodoform ga

FIG. 58.—THE EXTIRPATION OF THE SAC.
1. The sac is drawn upward and outward, and finally removed by the curved scissor are deeply introduced into the canal.

to exert pressure over the area, thus obliterating any of the
spaces. A compression bandage is used, and the patient
home, to return in two days provided there are no symp
Sutures removed upon the third day. A little dusting po
preferably xeroform, and the case is completed. Uninterr
recovery in a week."

The author has found that the excessive lacrymation and
ness of the eyeball disappeared in every case, although lacr
tion itself did not completely cease. There always seemed
more or less fullness of tears in the inner canthus, but as
passes on even this condition disappeared.

Prognosis.—Disease of the lacrymal passage, if untreat
always a source of danger to other portions of the eye. Th
fectious and virulent character of the secretions within the

mal sac in these conditions induces blepharitis, conjunctivitis, keratitis, ulcus serpens, etc. Their greatest danger lies in the ease with which they are overlooked. Operations, such as cataract extraction, that end in suppuration of the eye, can frequently be traced to such conditions. The application of the methods of treatment described will lessen this danger by the free drainage which is afforded. The epiphora may remain. The chronic form is most obstinate, the acute form resulting in free drainage by fistula formation, if untreated.

CHAPTER VI

DISEASES OF THE CONJUNCTIVA

BACTERIOLOGICAL researches of conjunctival secretions ultimately permit of a systematic classification of the various junctival affections based on their specifiç etiology. Pen further investigations on these lines, we must still content selves with classifying them according to their clinical mani tations, although we can already accord certain varieties a defir position, where the more or less constant presence of a cert organism or organisms has been demonstrated. As ophth mology has been keeping pace with bacteriology, the autl will begin to treat of the subject of conjunctivitis from tl standpoint.

THE BACTERIOLOGY OF THE CONJUNCTIVA

The conjunctiva of the new-born infant may be regarded free from bacteria. Rosenbauch has recently substantiated tl in 200 cases. They increase gradually in number during the fi few days, beginning after the first twenty-four hours, after whi time, in exceptional cases only, the conjunctiva will be fou to be free from bacteria. After the flora have settled, as a n they do not materially differ from that of subsequent ye (Axenfeld). This gradual and constant invasion of mici organisms is due chiefly to its proximity to the skin and exposı to the air, and such being the case it is surprising that soı observers have found as many as 30 to 50 per cent of ster conjunctivæ at different ages. In the writer's observations the were found only about 6 per cent, and taking into considerati this low percentage, it is his opinion that the conjunctiva c never be regarded as free from bacteria except for a short tiı

after birth. There is no doubt that the number of organisms, their nature and pathogenesis, vary considerably. It is a question whether the tears act as a germicidal agent; they do, however, act as a mechanical means of washing away bacteria from the conjunctival sac to the nasal cavity, so that the number of bacteria varies considerably at different times, and in some cases the conjunctiva may contain so few that it may be regarded as sterile. This condition, however, is only temporary, as new invasion, due to the constant exposure, is constantly taking place. The transference of bacteria from the conjunctiva to the nose may occur within twenty-four hours (Bach).

It is not the place here to go deeply into an exhaustive bacteriological technic indispensable for a thorough study of the great variety of bacteria found in the conjunctiva, nor into the special biological features of the same (a description of which can be found in text-books on bacteriology), but merely to consider briefly the morphology, and more especially to give to the clinicians the most important features in the diagnosis of the commonest pathogenic bacteria found in the different affections of the eye. The subject here is merely summarized so as to give the most essential points necessary to enable the physician to make a diagnosis in his own laboratory.

Among the bacterial flora found in the conjunctiva under normal conditions, the xerosis bacillus and several varieties of staphylococci have been found to predominate, the former being the more abundant. Thus the author found the xerosis bacillus in about 45 per cent of cases, staphylococci in about 30 per cent, tetragenous, prodigiosus, and mold in about 3 per cent respectively, and other organisms in about 10 per cent, while about 6 per cent did not show any growth on neutral agar. Among other varieties found were sarcinæ, proteus, bacillus subtilis, bacillus fluorescens, bacillus violaceus, etc.; other saprophytic bacteria, and bacillus coli were also found, though but rarely under normal conditions.

From the above results it may be seen that the conjunctiva contains constantly a certain number of bacteria, most of them saprophytic, the remainder, pyogenic bacteria, regarded as pathogenic; the latter under certain pathological conditions may

cause inflammation and give rise to what is known as conjunctivitis.

Conjunctivitis.—Although, as stated, some of the different kinds of conjunctivitis may be differentiated from a pathological and clinical point of view, our present knowledge does not permit of an accurate classification of the various forms of inflammation upon a bacteriological basis. It is only in exceptional cases that a certain kind of bacteria may be regarded as the sole cause of a given clinical type of conjunctivitis. Too often the bacteriologist places too much reliance upon his experiments *in vitro*, without taking into consideration the changes in the body, and the clinician expects all his difficulties to be solved by a culture tube. Adding to this the usual presence of other bacteria which *per se* have no relation to the etiology of the infection, it is imperative to treat the bacteriology of the conjunctiva apart from the clinical types and as far as possible to bring out their true relation.

Among the bacteria to which a true relation to infection has been attributed may be mentioned all the pyogenic microörganisms and the diphtheria bacillus.

Gonococci.—*Morphology.*—It is a bun-shaped diplococcus discovered by Neisser in 1879, easily stained by anilin dyes, and decolorized by the method of Gram. It is an almost obligate parasite and peculiar to man alone, for it is not found in other animals. Nothing is known of its saprophytic condition.

For diagnostic purposes, proceed as follows:

1. Make a smear on a cover-glass from the secretion or purulent discharge of the affected part, dry and fix by rapidly passing the cover-glass three times over the flame.

2. Stain with anilin gentian violet for about one to two minutes, following with Gram solution for about the same length of time.

3. Decolorize with absolute alcohol for about half to one minute until no color is imparted to the alcohol.

4. Counterstain with diluted carbol fuchsin for about one minute.

5. Dry, mount, and examine.

Under the microscope the gonococci appear red, while most other cocci retain the Gram stain. The gonococcus is characteristic in being found within the protoplasm of the leucocyte around

the nucleus, and is arranged in pairs, these conditions serving as differentiation from the staphylococcus, streptococcus, and pneumococcus.

Cultures.—The cultivation of the gonococcus is a difficult matter, and this condition in itself may be regarded as of great importance in making the diagnosis and differentiation from other diplococci, which grow well in ordinary culture media and are also Gram negative. Different culture media have been devised for the cultivation of the gonococcus, like blood serum, or a mixture of it with agar. The addition of human proteids to the ordinary media, likewise the addition of urine, etc., has been recommended, none of which, however, can be regarded at present as of practical value. The growth of the gonococcus, even when successful, is rapidly overwhelmed by the growth of other organisms with which it is usually associated in the purulent discharge, and even when a pure culture is obtained it soon dies.

Pathogenesis.—The gonococcus occurs most commonly in cases of inflammation of the eye as a severe type of ophthalmia neonatorum in new-born children or in the gonorrheal ophthalmia of adults, but may also be found occasionally as a metastatic infection.

The gonorrheal infection being invariably contagious, it is remarkable that the proportion of persons suffering from gonorrhea who have gonorrheal ophthalmia is so small; this doubtless is mainly due to the protection which the lid of the eye and tears afford. By some it is thought to be due to a certain degree of immunity conferred by the disease; this, however, seems doubtful, because of the sensitiveness of the gonococci to dehydration. It is probable, therefore, since a certain time elapses between the infection of the finger or linen in handling the part affected with gonorrhea and the contact of the infected material with the eye, that when the gonococci are deposited upon the conjunctiva they have already been killed or so weakened that they are incapable of giving rise to the infection. This view is in accord with the strictly parasitic condition of the gonococcus—in other words, its inability to live outside of the body. That the normal conjunctiva is very resistant or immune to the infection is scarcely to be regarded as correct, for experi-

ments have shown that infection takes place whenever freshly infected material is deposited on the eye. Another important consideration is the condition under which gonorrhea is contracted; that is, the congested condition during the orgasm most likely predisposes the part to the infection, while in the accidental deposition of the gonorrheal pus on the eye the conjunctiva is usually not in a congested condition, and therefore not predisposed to the infection.

Staphylococci.—*Morphology.*—It is a coccus, spherical in shape, nonmotile, rarely isolated or associated in pairs or in short chains, usually found in groups or masses. Easily stained by the anilin dye and takes the Gram.

Cultures.—It is easily cultivated in all ordinary culture media, and is a facultative anaërobic. The chromogenic properties are best obtained in the aërobic condition, under which, according to the color of the culture, three varieties are described, viz., Staphylococcus albus, Staphylococcus aureus, and Staphylococcus citreus.

Diagnosis.—The morphology, grouping, and coloration by the Gram, together with the culture characteristics, make the diagnosis very simple, and require no further description here.

Pathogenesis.—The Staphylococcus albus is the most common, and the Staphylococcus aureus the most rare, among those normally found in the eye, and though their constant presence in the normal conjunctiva and on the lid borders makes doubtful their etiological significance in ophthalmia neonatorum, membranous conjunctivitis, and other purulent infections of the eye in which they are abundantly found, there is sound reason to believe that these organisms, if not the primary cause of many inflammations of the eye, at least under congestive conditions of the conjunctiva take part in the infection and aggravate considerably the condition, and not uncommonly they may be regarded as the real and perhaps the sole cause of the infection.

Streptococci.—*Morphology.*—Spherical cocci, sometimes semioval, arranged in chains and nonmotile, easily stained by the anilin dye and also by the Gram stain.

Cultures.—Easily cultivated in the ordinary culture media, but the growth is less luxuriant than in the case of the

staphylococcus, and the culture dies relatively rapidly after two weeks.

Diagnosis.—The chain arrangement of the streptococci and the coloration by the Gram from a smear made from the suspected material readily give the diagnosis. Attention, however, should be given to the variations which the chains sometimes present. They may be very short, appearing as diplococci, or extremely long; likewise the individual cocci may be extremely small and spherical or of relatively large size. Not infrequently they are semioval, giving the appearance of short bacilli arranged in chains and resembling streptobacilli. In such cases the culture characteristics will serve as a means of differentiation from the streptobacillus type.

Pathogenesis.—The streptococcus type is not found in normal conjunctiva. Among the etiological significance attributed to this organism, two groups of affection are chiefly recognized, viz., the simple catarrhal conjunctivitis, known as Parinaud's lacrymal conjunctivitis, is a relatively rare affection. As a sequel of this pathological condition of the eye, this organism may give rise to the different varieties of iritis—simple, serous, and plastic iritis—as well as other complications of the affection of the eyes —eridocyclitis, kerato-iritis, etc.

Not uncommonly streptococcus is found to be associated with diphtheritical affection of the eye, and also with many inflammatory processes of the conjunctiva, in which cases it aids considerably in aggravating the pathological condition of the organ.

Pneumococci.—*Morphology.*—The pneumococcus is a diplococcus, oval in shape, usually associated in pairs and not infrequently forming short chains. Easily colored by the anilin dyes and also by the Gram coloration.

Cultures.—The pneumococcus grows in the ordinary culture media, but better in media to which about one third fresh blood is added. Usually the growth is not luxuriant and resembles that of the streptococcus. It dies quickly after a few days. It loses its virulence and vitality in about five days on solid media. In liquid culture media it lives longer, but the virulence disappears after the first week; moreover, the virulence is rapidly attenuated by successive cultivation, being completely lost after the third reinoculation.

Diagnosis.—The morphological aspect of the pneumococcus, the coloration by the Gram from a smear of the suspected material, and the culture characteristics readily give the diagnosis. One of the most reliable characteristics of the pneumococcus is its encapsulated appearance in preparations made from the exudate or purulent discharge of man and animals, as well as from albuminous liquid culture media. This characteristic is lacking when the pneumococcus is cultivated on the ordinary solid culture media. Care, however, should be taken not to confound the true pneumococcus with many other Gram positive diplococci abundantly found in the normal conjunctiva.

Pathogenesis.—The pneumococcus has been found to be the cause of the affection described as pneumococcic conjunctivitis and other inflammatory conditions of the eye. The affection sometimes has appeared in an epidemic form, but is not invariably contagious. Under certain conditions it may give rise also to typical hypopyon ulcers. Infection of the cornea by the pneumococcus is rare. Likewise this organism is rarely the cause of congenital purulent conjunctivitis.

Diphtheria Bacillus.—The diphtheria bacillus is a rod-shaped organism of variable size, nonmotile, easily colored by the anilin dyes and also by the Gram method of coloration.

Cultures.—The diphtheria bacillus is an aërobic organism rarely cultivated in the ordinary culture media, requiring for its rapid growth blood serum, and in such condition under favorable temperature retains for a long time its virulence and vitality.

Diagnosis.—The morphological appearance, the coloration by the Gram, and the culture characteristics, should all be considered in making the diagnosis. Special attention should be given in regard to the size, form, and arrangements of the bacilli. Three different sizes are usually encountered:

1. Bacilli very short, almost coccoid in form, usually associated in pairs, resembling diplococci or parallel to each other, sometimes appearing in short chains made of 3 or 4 cells.

2. Bacilli of medium size, arranged as diplobacillus or parallel to each other; often, however, lying at an angle resembling a V shape.

3. Long bacilli, often arranged in pairs, parallel to each other, or forming a V or X, sometimes L shape; very commonly they

appear as isolated organisms very irregular in shape and of great variation in the condensation of the protoplasm, thicker at one end, giving a pear-shaped appearance, or the thickening may be seen at the middle of the bacillus. Not uncommonly the condensation of the protoplasm is so irregular that the bacillus appears as if made of short chains of cocci or gives the appearance of spores. In this case the bacillary form, however, should be distinctly determined before making the diagnosis. Careful scrutiny will show the appearance to be due to irregularity in the protoplasm of the same bacillus, and also that they are not spores. The considerable morphological variation peculiar to the diphtheria bacillus is an important consideration, and the coloration by the Gram should be a routine procedure in making the diagnosis. In case of doubt, the culture characteristics must be considered, and inoculation of lower animals should be resorted to in order to differentiate this bacillus from many other organisms which it resembles.

Pathogenesis.—The diphtheria bacillus is the cause of membranous conjunctivitis. This should not be confounded, however, with the milder or croupous form which may be caused by other organisms. The types of conjunctivitis caused by the diphtheria bacillus vary considerably, but it is almost always membranous. Both its local and general symptoms may differ considerably. True diphtheritic affection is usually, though not always, necrotic and malignant. Not uncommonly the streptococcus and the staphylococcus precede the diphtheritic infection of the eye.

Xerosis Bacillus.—This bacillus presents the same morphological and cultural characteristics as the diphtheria bacillus. It is found in xerosis, but on account of its frequent occurrence in the normal conjunctiva, it is not to be regarded as the cause of this affection.

The Morax-Axenfeld Diplobacillus.—*Morphology.*—The cover-glass preparations of this organism are quite characteristic. It generally occurs in pairs, resembling a diplobacillus, often, however, in chains; it is stained by the anilin dyes and decolorized by the Gram. Capsules are sometimes observed which can be demonstrated by special capsule stain, but observers differ as to the existence of a capsule. Morax believes the bacillus to be capsule free. Gifford does not.

Cultures.—As in the case of the gonococcus, cultures of this bacillus are obtained with difficulty and only on media containing blood serum.

Diagnosis.—The diagnosis is based on the morphology—that is the appearance as a Gram negative diplobacillus, occasionally arranged in chains, and the difficulty in cultivating the organism on the ordinary culture media.

Pathogenesis.—This microörganism is the cause of the most common of catarrhal conjunctivitides, a non-membranous blepharo conjunctivitis with a typical erythema of the edges of the lid, a slight maceration of the skin, most marked at the angles (angular conjunctivitis), a noncopious watery secretion, and not uncommonly superficial infiltration of the cornea. The affection is extremely contagious.

Koch-Weeks Bacillus.—*Morphology.*—This bacillus appears as very short, fine rods lying end to end, generally appearing either as a diplobacillus or forming chains of 2 or 3 links. Sometimes they appear in pairs, parallel to each other. It is easily stained by the anilin dyes, especially by diluted carbol fuchsin, and is decolorized by the Gram. The ends are rounded and often show a deeper polar staining.

Cultures.—As with the gonococcus, the cultivation of this organism is attended with great difficulty, requiring a medium containing blood serum.

Diagnosis.—The morphology of this organism, as fine, rod-shaped diplobacillus with rounded ends, stained less deeply than the nuclei of the cells, lying between the leucocytes or in the protoplasm, and the decolorization by the Gram, render the diagnosis readily. Care should be taken, however, not to confound this organism with the influenza bacillus.

Pathogenesis.—This microörganism is regarded as the most common cause of an acute, mucopurulent, contagious conjunctivitis. The cornea is rarely affected, and then only by a small gray superficial infiltration. Central perforation has been described, and also the production of a pseudo-membranous conjunctivitis or a chronic conjunctivitis.

Bacillus pyocyaneus.—*Morphology.*—The bacillus pyocyaneus is a rod-shaped microörganism, variable in size, appearing as a short, thick bacillus or in relatively long segments.

Under certain conditions it may present long filamentous forms. It is easily stained by the anilin dyes and also by the Gram.

Cultures.—It is easily cultivated in the ordinary culture media, and under aërobic conditions imparts to the cultures a bright green coloration.

Diagnosis.—The morphology, coloration by the Gram, and chromogenic properties on the culture media, render the diagnosis easy. Another point to be considered is the characteristic green color of the pus in inflammatory processes where this microorganism is present. This, however, is sometimes lacking.

Pathogenesis.—This bacillus has been found in cases of superficial and purulent keratitis. It may produce rapid sloughing of the cornea, followed by panophthalmitis; not infrequently this microörganism is associated with others infecting the eye.

Bacillus coli communis.—*Morphology.*—Bacillus coli usually appears as a short, rod-shaped bacillus, but not infrequently as a long bacillus or even a short filament. It is easily colored by the anilin dyes and decolorized by the Gram.

Cultures.—It is easily cultivated in ordinary culture media, and in dextrose broth attacks the sugar with the evolution of gas.

Diagnosis.—Its morphology, decolorization by the Gram, and biological characteristics render the diagnosis easy.

Pathogenesis.—This bacillus has been found in cases of traumatic panophthalmitis, in ophthalmia neonatorum, in pseudomembranous conjunctivitis, and in hypopyon keratitis. Not infrequently Bacillus coli is also associated with other purulent inflammations of the eye. Zur Nedden (*Zehenders Klin. Monat. f. Aug.*, xl, 1902) demonstrated it as the cause of a case of hypopyon keratitis (Parsons).

Bacillus pneumoniæ (*Friedländer*).—This microörganism has been found in cases of pseudo-membranous conjunctivitis and also in the conjunctival sac of the new-born. Its pathogenic properties, however, have not been well determined.

Bacillus influenzæ.—Affections of the conjunctiva have been traced to this microörganism, but it cannot be distinguished morphologically from the Koch-Weeks bacillus. Inoculations on the human conjunctiva have had no result (Axenfeld).

DISEASES OF THE CONJUNCTIVA

CONJUNCTIVITIS

Definition.—An inflammation of the conjunc
from simple injection of the blood-vessels to ext
logical changes, and characterized by more or less
abnormal secretion, and alteration in the appear
structure.

The most important affections to which the conjun
ble are inflammatory in character, and are preceded by
of hyperemia or overfilling of the blood-vessels. This
tival hyperemia is not restricted to the inflammatory
but is common to all conditions which in any way irr
membrane, such as foreign bodies, growths, inflamm
other ocular structures, intranasal, or constitutional
(gout), infectious diseases, exanthemata (measles, etc.
may be a symptom of ametropia. It is often spoken of
junctival injection, and should be distinguished from *cilia*
jection, which indicates more serious conditions. The co
tival injection is derived from the posterior conjunctival ve
is most marked in the fornix, fades as the cornea is approa
is bright red in color, is superficial, and can be moved by pres
upon the lid.

Ciliary injection, on the other hand, takes its origin from
anterior ciliary vessels, is most marked directly around the c
nea, fading toward the periphery of the globe, is pink or lilac
color, and on account of its deep situation cannot be moved
displacing the conjunctiva. It accompanies disease of the corn
iris, and ciliary body. Ciliary injection of a pronounced vi
color is always venous in origin, and is most marked in scler
and glaucoma. In extremely severe ocular inflammations
two may coexist.

HYPEREMIA OF THE CONJUNCTIVA

SYNONYMS: *Hyperemia palpebraris; Dry catarrh.*

Definition.—A condition characterized by hyperemia of
conjunctival blood-vessels, enlargement of the follicles of the c
junctiva, particularly in the palpebral region, and slight gen

℞ Acidi borici	....	gr. xx;	1.2
Sodii chloridi	....	gr. xv;	1.0
Aquæ camphoræ, Aquæ destillatæ,	....	āā fl ℥ij;	60.0

Misce. Sig.: Drop freely into eye three times daily.

or

℞ Zinci sulphatis	....	gr. j–ij;	0.06–0.12
Aquæ destillatæ	....	fl ℥j;	30.00

Misce. Sig.: Drop in affected eye three times daily.

A few drops of a very weak solution of zinc chlorid may be instilled in the eye at night in very severe cases.

SIMPLE CONJUNCTIVITIS

SYNONYMS: *Catarrhal conjunctivitis; Conjunctivitis catarrhalis; Catarrhal ophthalmia.*

In this condition we have in addition to hyperemia an abnormal discharge, which in the milder forms is usually confined to the palpebral conjunctiva and its transitional folds, the plica semilunaris being usually swollen as well.

The disease is almost always bilateral, and while it occurs in persons of all ages it is more frequently seen in young individuals. The cases are more numerous in spring and autumn than at any other time of the year.

Symptoms.—Photophobia, lacrymation, and pain on employing the accommodation are significant symptoms. In very severe cases the bulbar conjunctiva is also affected. The discharge varies from a watery to a mucopurulent consistence, often causing the lids to adhere in the morning. Vision is unaffected, the obscuration complained of being due to flakes of mucus adhering to the corneal surface. In severe cases numerous bacteria are present, especially staphylococci, streptococci, and pneumococci. Various other organisms found in certain clinical types of conjunctivitis are also found, but our knowledge as yet does not permit us to say what their precise relations are to the inflammations they are associated with.

Treatment.—The treatment of simple conjunctivitis is largely symptomatic. All sources of irritation, direct or reflex, should be

removed. Ametropia should be corrected and soothing eye washes (see Hyperemia of the Conjunctiva) employed.

ACUTE CONTAGIOUS CONJUNCTIVITIS

SYNONYMS: *Epidemic ophthalmia; "Pink eye"; Acute catarrhal conjunctivitis; Koch-Weeks bacillus conjunctivitis; Epidemic conjunctival catarrh.*

Definition.—An acute catarrhal inflammation of the conjunctiva arising as a result of contagion, and manifesting itself, as a rule, in epidemics. Whether it is an aggravated form of simple conjunctivitis or a distinct affection, is as yet subject to differences of opinion.

Etiology.—It is due, in most cases, to the presence of the Koch-Weeks bacillus, a rod-shaped microörganism measuring 1 to 2 μ in length and 0.25 μ in breadth, and resembling very much the influenza bacillus and that of mouse septicemia. This organism was discovered independently by Koch while in Egypt, and by Weeks, of New York. The latter observer succeeded in growing a pure culture of the bacillus, and its cultural characteristics were made the subject of a complete study by Morax. It stains readily with the anilin dyes. In the vicinity of Philadelphia the more frequent cause of epidemic conjunctivitis has been found to be the pneumococcus of Fränkel. The disease is most prevalent in the fall and spring, when the weather is subject to marked variations. The discharge is infectious, and the disease is disseminated in many instances by unclean towels, handkerchiefs, etc. The affection is common in schools, orphan asylums, barracks, etc.; public baths are undoubtedly prolific sources of contagion. No age, except very early infancy, is exempt.

Symptoms.—After an incubation period of about thirty-six hours the initial manifestations of simple conjunctivitis appear, which become very intense after two or three days. One eye is usually affected first. This acute stage is marked by intense congestion, mucopurulent discharge, photophobia, a circumcorneal serous exudation known as *chemosis*, and sometimes pseudomembranous formation. Long strings of the mucopurulent secretion frequently gather in the *cul-de-sac*. This stage lasts about ten days, but the entire course of the disease is seldom

more than two weeks. Corneal complications are rare. The disease is bilateral.

Diagnosis.—The microscope will serve to detect either the Koch-Weeks bacillus or the pneumococcus, but in the absence of such findings the history and clinical manifestations are sufficiently reliable for purposes of diagnosis.

Treatment.—Whenever practicable the patient should be removed to more hygienic surroundings and separated from other individuals in order to prevent contamination. Cleanliness is of prime importance. The local application of iced compresses will afford relief. The use of astringent lotions, such as the chlorid-of-zinc lotion (1 grain (0.06) to the ounce (30.0)) recommended by Gifford are of value. Bichlorid-of-mercury solution (1–10,000) has been recommended by Weeks. The treatment advised in catarrhal conjunctivitis is also applicable.

Prognosis.—Recovery within two weeks is the rule, but recurrences are common.

DIPLOBACILLUS CONJUNCTIVITIS

SYNONYMS: *Angular conjunctivitis; Subacute conjunctivitis; Diplobacillary conjunctivitis (Morax-Axenfeld).*

This variety of conjunctivitis is caused by a diplobacillus discovered by Morax and Axenfeld, and subsequently studied by Peters and Harold Gifford. The average size of the organism is from 2 to 3 μ in length and from 1 to 1.5 μ in breadth (Morax). It is rapidly and completely decolorized by Gram. The line of separation between the bacilli can be clearly seen (see Bacteriology). A bacillus has been described by Petit which is somewhat analogous to that of Morax and Axenfeld, but which differs somewhat in its pathogenicity (*diplobacille liquéfiant of Petit*).

Symptoms.—The disease is slow and protracted in its development, beginning with redness of the lid borders and adjacent conjunctiva—in short, a blepharo-conjunctivitis. The secretion is scant and frequently collects and adheres at the canthi, more frequently at the internal one (angular conjunctivitis). The affection may attack all ages, but is more common in adults.

Diagnosis.—The diagnosis is usually made from the clinical picture, but in doubtful cases the bacteriological examination will elucidate the situation.

Treatment.—The *zinc salts* are practically *specific* in this variety of conjunctivitis, the following prescription illustrating one of them:

℞ Zinci salicylatis .... gr. j–v; 0.06–0.3
Aquæ camphoræ, } .....āā fl ℥ij; 60.00
Aquæ destillatæ, }
Misce. Sig.: Drop freely into eyes three to four times daily.

PNEUMOCOCCUS CONJUNCTIVITIS

Although primarily described as a disease of early childhood, later observation has shown that no age is exempt. As its name implies, it is caused by the diplococcus of Fränkel and Weichselbaum, and although distinctly contagious and at times epidemic, it is not as markedly so as the conjunctivitis due to the Koch-Weeks bacillus. The geographical distribution of this variety of conjunctivitis is not as extensive as would be supposed when considering the universal distribution of the pneumococcus itself.

Symptoms.—Both eyes are affected, there being usually a thin mucopurulent discharge, becoming thicker as the disease progresses, resembling at times the acute mucopurulent conjunctivitis. Subconjunctival hemorrhages and edema may occur. The duration is usually from five to ten days. The prognosis is favorable.

Treatment.—The usual antiseptic collyria will generally suffice in the treatment of this variety of conjunctivitis.

INFLUENZA BACILLUS CONJUNCTIVITIS

This form of conjunctivitis usually accompanies influenzal infection of the upper respiratory passages, the lacrymo-nasal passage, or the middle ear. The greater number of cases occur in young infants, the conjunctiva of the adult being more resistant. It affects chiefly the palpebral conjunctiva, and is characterized by a rather free, thin discharge. It may be pseudo-membranous in character, as in a case reported by Arnold Knapp.

Treatment.—Cold compresses are of particular value in addition to the usual eye lotions.

EXANTHEMATOUS CONJUNCTIVITIS

This is a conjunctivitis accompanying various exanthemata, being particularly prominent in measles. In the latter affection it may attain a severity to the extent of causing inflammation and suppuration of the Meibomian glands of both lids (Fuchs). In smallpox the conjunctiva may be the seat of pustules, which, if near the corneo-scleral junction, may cause dangerous complications of the cornea. In leprosy, psoriasis, herpes, lupus, acne rosacea (acne rosacea conjunctivæ of Arlt), the conjunctiva may participate in the inflammation.

Treatment.—The treatment is essentially that of the various diseases causing the inflammation, together with soothing and antiseptic collyria. The application of a solution of nitrate of silver, gr. ss (0.03) to ʒj (4.0) daily, is valuable in this variety of conjunctivitis.

TOXIC CONJUNCTIVITIS

Irritative conjunctivitis may follow the application of calomel powder to the eye, the anilin dyes accidentally introduced, stings of insects, and stimulating ointments used for skin diseases in the immediate neighborhood of the eyes.

Treatment.—In all cases the employment of the irritant should be discontinued. The treatment is similar to that recommended for simple conjunctivitis. Silver nitrate, gr. ss (0.03) to distilled water 1 dram (4.0), followed locally by the following lotion, is very beneficial:

℞ Acidi borici, Sodii biboratis,	āā ʒss;	2.00
Aquæ menthæ piperitæ	fl ʒiij;	12.00
Aquæ hamamelidis	fl ʒiv;	15.00
Aquæ camphoræ, Aquæ destillatæ,	āā fl ℥ij;	60.00

Misce. Sig.: To be dropped freely into eyes several times daily.

DRUG CONJUNCTIVITIS

SYNONYMS: *Atropin conjunctivitis; Atropin catarrh (Fuchs).*

Follicles of the conjunctiva, together with catarrh, frequently occur as a result of the instillation of atropin, cocain, eserin, homatropin, and duboisin, although it is more common where atropin and cocain are applied. The author has found that atropin poisoning takes place in 1 to 4,000 patients, and cocain in 1 to 200, in prolonged use of the drugs. Considerable swelling of the lids may occur. The follicles are more abundant on the conjunctiva of the lower lid. This variety of conjunctivitis is more frequent in adults.

Etiology.—Idiosyncrasy is undoubtedly present in a certain number of cases. The conjunctivitis may be due to chemical or bacteriological contamination either in the collyria themselves or the pipette. The patients are usually of the blonde type, with delicate skins.

Treatment.—This consists of discontinuing the use of the drug causing the conjunctivitis and the instillation of soothing eye washes. A 1-per-cent solution of creolin has been found of service (De Schweinitz). It is sometimes of value to change the alkaloid, or else combine it with an astringent.

LACRYMAL CONJUNCTIVITIS

Lacrymal conjunctivitis, as its name implies, is the result of continued irritation of the conjunction from inflammations of the lacrymo-nasal passages, especially dacryocystitis. It is in these cases the infection often extends to the cornea to the extent of inducing perforation and destruction of the eyeball. *In all cases of unilateral conjunctivitis the lacrymal passages should be carefully examined.*

Treatment.—Free drainage of the lacrymo-nasal passages must be maintained. In addition the usual remedies for chronic conjunctivitis are indicated.

PURULENT CONJUNCTIVITIS

SYNONYMS: *Purulent ophthalmia; Conjunctival blennorrhea; Contagious, military, or Egyptian ophthalmia; Ophthalmia neonatorum; Gonorrheal ophthalmia.*

Definition.—A specific conjunctival inflammation with purulent discharge, nearly always due to infection by gonococci.

The various forms of purulent conjunctivitis are distinguished from mucopurulent conjunctivitis by their greater severity, and by the fact that they are much more highly infectious.

A variety of this disease has been observed in patients suffering with gonorrhea, in whom direct infection of the eye has been excluded; in such cases the disease is less severe.

Symptoms.—Within a period varying from a few hours to several days after the infection—depending upon the virulence of the microörganisms—the eye presents the symptoms of mucopurulent conjunctivitis. The inflammation rapidly increases in severity, there is excessive swelling of the lids, and copious discharge. The lids are very sensitive to pressure, and in the earlier stages of the disease they are tense, and very often smooth and shiny; in the later stages they become softened. The lids are so swollen that the patient is unable to open them, and the physician may have considerable difficulty in obtaining a view of the cornea.

The discharge, which at first is clear and watery, may contain shreds and flakes of mucus and may even be discolored. It becomes more purulent within twenty-four or forty-eight hours, until it presents a typical appearance—a creamy, slightly greenish-yellow pus.

Three varieties of purulent conjunctivitis are distinguished:

1. Ophthalmia neonatorum.
2. Gonorrheal ophthalmia.
3. Purulent, nongonorrheal, conjunctivitis.

Ophthalmia Neonatorum

SYNONYMS: *Blennorrhea neonatorum; conjunctivitis neonatorum.*

Ophthalmia neonatorum is the term applied to the purulent conjunctivitis in the new-born, which is due to the infection of

the child's eyes during birth by the purulent discharge from the vaginal canal or uterine cervix of a mother who is suffering from leucorrhea or gonorrhea. This is a serious condition, and is remarkable in that it causes more blindness than any other single cause. (Statistics show that in the United States 30 per cent of the blind have lost their sight as the result of ophthalmia neonatorum and its sequels.) Cases have been reported in which the disease was present *in utero*, due to the premature rupture of the membranes, and, on the other hand, other instances of the disease have been observed as late as three or four weeks after labor.

It is customary to consider the disease as a form of gonorrheal ophthalmia; but, while the affection may, in the majority of cases, be traced to infection by gonorrheal discharges, there are cases in which other factors are potent. That it was possible to transmit gonorrhea to the eye by contact was first discovered by F. Jaeger, but that the medium of contagion was the discharge was pointed out by Piringer in 1839. With the discovery of the specific diplococcus of gonorrhea by Neisser in 1879 the true pathology of this form of ophthalmia was at once demonstrated.

The worst form of the disease is, without a doubt, caused by infection of the conjunctiva by leucorrheal discharges during the passage of the child through the birth canal. The examination of the discharge from the eyelids in this affection has shown the presence of the gonococcus of Neisser in most cases, but occasionally streptococci and the Klebs-Löffler bacillus have been found.

Symptoms.—In a typical case it is common to observe on the morning of the third day after birth a swollen condition of the upper eyelid, the edge of which is red and the eyelashes are glued together by a mucopurulent secretion, which has dried upon them overnight. The affection begins as an ordinary inflammation of the conjunctiva, but rapidly reaches its height, becoming purulent in character within a short period, as in gonorrheal ophthalmia in adults. The discharge at first resembles serum or mucus, but soon becomes thicker and assumes a diversity of color according to the intensity of the inflammation being whitish, yellowish, greenish yellow, and sometimes mixed with blood. It accumulates rapidly and is prevented from escaping

by the swollen condition of the lids and the dried discharge which mats the lashes together. Herein lies the great danger of the disease, as the bacteria are thus allowed to multiply rapidly and assume greater virulence, attacking structures which are unable to resist their onslaught. An attempt to open the lids and examine such an eye is not devoid of danger to the examiner, as particles of pus may be ejected into the surgeon's eye upon releasing the tension of the lids.

One eye is usually affected first, the other optic being attacked within a few days. Chemosis of the bulbar conjunctiva is not as frequent as in gonorrheal ophthalmia of adults, the swelling of the lids being the most marked feature. The affection seems to remain stationary for a period of about ten days after having reached its acme, during which the cornea shows slight haziness and pericorneal injection. About the twelfth day the disease is apt to assume an opaline tint and progress toward ulceration unless it is checked by appropriate treatment. The infiltration of the cornea with pus may be slight, or may extend, speedily destroying the texture of the cornea, resulting in its ulceration and perforation, with prolapse of the iris and injury to the lens. The corneal involvement in this disease is its most unfortunate feature. At best, vision is markedly diminished by the corneal opacities, and blindness is by no means uncommon. Fully one third of the blind in the asylums owe their infirmity to this affection, and the gravity of the condition is intensified when we consider that the sight is lost before the patient has become at all adapted to his surroundings, thus making him a ward of the community for a lifetime.

Diagnosis.—The violence of the symptoms of conjunctival inflammation, the rapid progress and extent of the swelling, and the free watery and flocculent discharge are the first points that lead to a suspicion of purulent conjunctivitis. If shortly after a child is born (twenty-four hours) a slight discharge makes its appearance, the probability is that we have to deal with ophthalmia neonatorum, and it should be at once treated accordingly. Microscopic examination of discharge will aid very greatly in distinguishing it from less virulent affections, but the treatment should not be deferred for the microscopical findings.

Prophylaxis.—It should always be ascertained whether or not

the mother has had a discharge from the vagina, either mild or profuse, before the birth of the child. If a discharge has existed, it should act as a stimulus to greater watchfulness on the part of the attending physician, and every energy should be bent toward preventing development of the ocular disease in the infant. The eyes of the child are, as a rule, in such cases infected while passing through the birth canal, but the development of the disease can usually be prevented if proper measures are applied. The eyes of every child should be immediately cleansed after birth, and a 2-per-cent solution of silver nitrate freely instilled. This prophylactic measure is due to Credé; if it were adopted as universally as it deserves to be, the disease could generally be prevented. In some foreign countries Credé's prophylaxis is made compulsory by law.

The disease is generally bilateral; if, however, one eye only is affected at the time the case comes under observation, the healthy eye should be protected by a Buller's shield, or a light compress of cotton securely fastened.

Treatment.—Infection occurs during delivery, although, in rare cases, children are born with the inflammation already developed, having probably been infected shortly after an early rupture of the membranes in a slow labor. A few cases become infected subsequently to labor from lack of proper cleanliness.

The treatment is based on the same principles which apply in the treatment of gonorrheal ophthalmia, allowance, of course, being made for the difference in the patients' ages and constitutions.

The child's head should be placed between the knees of the physician, the rest of the body of the child being held by the nurse; the upper lid is raised by means of a retractor, when the swelling is not too great, and thoroughly cleansed, and irrigated every hour, until the discharge has diminished or has altogether ceased.

Once a day the lids should be everted, the child being held in the same position, and an application of nitrate of silver (0.3), 5 grains to the ounce (30.), made; this should be followed in one hour by a boric-acid solution or the following lotion, which is in great favor in the treatment of all purulent discharges of the eyelids:

℞ Hydrastinæ hydrochloridi	gr. iv–vj;	0.2–0.4
Acidi borici	gr. xx;	1.20
Tincturæ opii deodorati	fl ʒij;	8.00
Aquæ destillatæ	fl ℥iv;	120.00

Misce. Sig.: Drop freely into eyes several times da

Adrenalin (1–3,000) may also be applied four tin to assist in contracting the blood-vessels, and will tend vent the liberation of serum, and thereby lessen the pr ucts.

FIG. 59.—IRRIGATING BOTTLE.

Iced pledgets of cotton must be a wrung out in 1–2,000 or weaker bic of-mercury solution, but they need r changed as often as in the more active of this disease. For the method of p ing cold dressings, see Treatment of G rheal Ophthalmia. They should alway used in addition to the nitrate-of-silver t ment or protargol, 20-per-cent solution.

GONORRHEAL OPHTHALMIA

Gonorrheal ophthalmia is the term given to the form of c junctivitis caused by infection of the urethra, the infective m rial being carried directly to the eye by the hand, towel, hand chief, etc.

Symptoms.—The symptoms first appear from a few hour two or three days, depending upon the virulence of the infect After its onset the clinical course of the disease is not unlike of the new-born. Frequently the discharge is sero-sanguinous sides being purulent. The severer the conjunctivitis, and in ticular the more pronounced the participation of the conjunc bulbi in the inflammation, the more certain is involvement of cornea to take place (Fuchs). The time of the corneal invc ment is also in more or less direct proportion to the severit the infection. The organisms are quite tenacious, gonococci l ing been found in the conjunctival sac for days and weeks a

the discharge is lessened, the strength
the intervals of application increased
weakened to 1-5,000, in which s
as pus is found in the conjunctiva
of cold by means of pledgets of l
in allaying the pain, but also ser
These pledgets are applied conti
diminution of the discharge is no
prepared, and into this a smaller bow
is poured into the smaller bowl an
in it—a dozen or more at a tim
and applied to each closed eyelid
They are then thrown away an
from the bowl. The following
marked edema of the eyelid:

....	gr. iv;	0
....	gr. xij;	0
... ... mae. }	.āā fl ℥ij;	8
... ae. } ... ae. }	.....āā fl ℥ij;	60

locally several times daily.

a few drops of a 20-per-c
to the conjunctival sac. Duri
applied eserin (½ grain (0.03 gr
very good results in cases in w
appearance, or the following:

...atis	gr. ij;	
...hydrochloridi	gr. x;	
...ae. } ...atae. }	......āā fl ℥ij;	60

Used where there is a membrane

treatment, the cornea breaks dow
acetic acid is applied directly to
hours. The most strenuous ef

conclude that it is still the sovereign remedy where indicated in ocular diseases, and that it has not yet been excelled by other silver preparations.

Metastatic Gonorrheal Conjunctivitis

Synonyms: *Endogenous gonorrheal conjunctivitis* (Haltenhoff).

It is now an established fact that gonorrheal conjunctivitis may occur as a metastatic affection. It is usually found in cases where the articulations are involved. According to Neisser and Bumm, it will usually be found that in such cases the initial lesion in the urethra is a mixed infection. The symptoms are milder than in the cases where the conjunctiva is directly inoculated, although ulceration of the cornea may follow. We are sometimes confronted by cases in which it has to be decided whether we are dealing with a mild conjunctivitis due to direct inoculation with gonococcus, or a conjunctivitis due to metastasis. According to Fuchs, the gonococci can be found in even a mild case of acute blennorrhea, so long as it is still recent, but are not found in metastatic conjunctivitis. Yet, according to Morax and Axenfeld, the absence of the gonococcus is not at all significant, Noble, in a series of experimental investigations, having shown that the organism lies in the tissues and walls of the vessels of the conjunctiva, and may give rise to an inflammation without being demonstrable on the surface of the mucous membrane. Metastasis from an initial infection of the conjunctiva by the gonococcus as well as intra-uterine infection, while rare, have been described (Deutschmann).

Treatment of this form of conjunctivitis is essentially that of the usual inflammations of the conjunctiva. In a most pronounced case of this variety of conjunctivitis which the author saw in consultation with Dr. David P. Huston, the ordinary treatment proved ineffectual, and it was only after three injections of antigonococcic serum that the conjunctival injection cleared up. In another case seen in the out-patient department of the Medico-Chirurgical Hospital a similar treatment was instituted, and the patient rapidly recovered. While the author's experience in this direction is limited to two cases, the results were so marked that he feels the treatment can

be recommended as a valuable addition to the therapy of the disease.

In young girls the conjunctiva has become infected through contact with vaginal discharges. In some of these cases the gonococcus could be demonstrated where children had acquired the disease from other women, or where the infection had been transmitted by clothes or toilet articles. The symptoms are like those of ophthalmia neonatorum, but less severe. The *treatment* is that of the former affection.

PROGNOSIS AND SEQUELÆ OF PURULENT CONJUNCTIVITIS

Skillful treatment will save the eye in almost all cases of ophthalmia neonatorum, and in a large proportion of the violent cases of gonorrheal ophthalmia, provided it is instituted early enough.

Corneal ulcer and perforation are the tragical results that are to be feared if the case does not come under treatment early in its course, or if the treatment is unsuccessful. Corneal perforation may result in prolapse of the iris, anterior synechia, anterior staphyloma, and probably hopeless blindness.

The process of involvement of the cornea is not well understood, but it is, in all probability, due to direct infection by the virulent discharge. This infection is rendered easier by the obstruction offered to the nutrition of the cornea. In addition the gonorrheal pus is constantly against the corneal surface, in severe cases eventually macerating the epithelium. The pressure of the swollen lids on the cornea, as well as of the chemosis surrounding the cornea, interferes with the normal anastomoses, and the nourishment of the cornea is so badly impaired that necrosis takes place.

When the cornea becomes involved, a small ulcer usually develops near the lower and outer corneal margin, which extends rapidly both in area and in depth; or a considerable portion of the cornea—usually at the center—becomes opaque and breaks down, leaving a large, rapidly progressive ulcer, which is very apt to cause perforation and bring about a serious termination.

PURULENT NONGONORRHEAL CONJUNCTIVITIS

The gonococcus is not always the cause of a purulent conjunctivitis. Trachoma and diphtheritic conjunctivitis are at times accompanied by a purulent secretion. Both the pneumococcus as well as the Koch-Weeks bacillus may cause a conjunctivitis of such intensity that it becomes purulent. In 42 cases of purulent conjunctivitis Gonin found the gonococcus 28 times, the Koch-Weeks bacillus 8 times, the staphylococcus and streptococcus each once. In addition, there were 2 varieties of organisms the nature of which could not be determined, and in 2 cases no bacteria. J. Herbert Parsons [1] has had similar experiences.

Treatment.—In this form of conjunctivitis the same treatment is indicated as in other acute conditions—cleanliness, eye lotions, topical applications, and attention to the general condition of the patient. The discovery of the Klebs-Löffler bacillus is an indication for the immediate employment of diphtheria antitoxin. The following is of decided value:

℞ Zinci phenosulphonatis	gr. v–xx;	0.3–1.2
Aquæ menthæ piperitæ....	fl ʒiij;	12.0
Aquæ camphoræ, Aquæ destillatæ, }	āā fl ℥ij;	60.0

Misce. Sig.: Drop freely into eyes three to four times daily.

CROUPOUS CONJUNCTIVITIS

SYNONYMS: *Plastic conjunctivitis; Pseudo-membranous conjunctivitis; Croupous ophthalmia.*

Croupous conjunctivitis appears to be essentially nothing more than a catarrh of great severity in which the intensity of the inflammation has led to the production of a false membrane. It occurs in childhood, but the student should remember that it has no connection with laryngeal croup.

Symptoms.—The initial symptoms are those of violent catarrhal ophthalmia. The lids are edematous, there is swelling of the conjunctivæ, and an abundant mucopurulent discharge. A few days after the onset of the disease, the palpebral portion of the

[1] "The Pathology of the Eye."

conjunctiva is found covered in patches, or sometimes in its entire extent, by a whitish-gray membrane, much resembling that observed in diphtheritic conjunctivitis, although it is more superficial. If this membrane be torn away the exposed surface bleeds very freely. After a time the membrane separates spontaneously, leaving the surface of the conjunctiva in much the same condition as in the later stages of severe catarrhal inflammation. It may occur as the result of microörganism infection or as the reaction to thermal or chemical irritants. Systemic complications may occur as in a remarkable case reported by Hansell in which gangrenous stomatitis coexisted.

Treatment.—This condition does not respond readily to treatment, and no energetic measures should be taken as long as the croupous membrane is present. Iced compresses on the eyelids, as well as leeches applied to the temple, are of great service. Removal of the membrane does not appear to be of any value, and as it induces bleeding, it is better to leave it undisturbed. Caustics should not be applied until the false membrane has disappeared. If for any reason the membrane is removed, it should not be torn off roughly, as small hemorrhages that are rather difficult to control are very apt to result. The eye should be freely washed with a mild antiseptic lotion. After irrigation a few drops of a 25-per-cent solution of boroglycerid should be dropped into the eye. Enzymol (50-per-cent solution) has given good results in the hands of the author. When applied to structures of the eye in which there is loss of nutrition (ulcers of cornea), it has the power of dissolving those areas by its proteolytic action, the latter ceasing when the substance comes in contact with healthy tissues.

Protargol, in a 20-per-cent solution, was used most successfully by the author in one of his cases, the membrane disappearing after the second day.

Mercury, administered internally, is of great service, and the ointment should be applied locally to the temples. General stimulation has been found very beneficial, and should be resorted to in all forms of conjunctivitis. Chlorate-of-potash solution has been recommended.

Prognosis.—The prognosis is favorable. The deposit is usually limited to the surface of the lids, and the cornea very rarely

becomes involved. Rigorous prophylaxis should be observed when the affection is monocular, and in this connection Buller's shield is extremely useful.

DIPHTHERITIC CONJUNCTIVITIS

Diphtheritic conjunctivitis is a very rare disease, being more common in Europe than in this country. It is almost exclusively confined to children, although occasionally cases of the disease in adults have been reported.

If, on everting the lids in an incipient case of conjunctivitis, small areas of a pale gray color, infiltrated with rigid material that strongly resists the eversion of the lids, are found, and infiltration of the conjunctiva is also observed, diphtheria of the conjunctiva should at once be suspected.

Symptoms.—The lids are tense, on account of the rapid and great swelling, very hot, and exquisitely tender to the touch. The boardlike stiffness of the lids may be so marked that they can scarcely be opened, and may be everted only under anesthesia. There is generally high fever. In purulent ophthalmia, on the other hand, although the eyelids may be greatly swollen, they are soft, flaccid, and are not painful to the touch, nor is the temperature very high, and the lids may be readily everted.

The paler areas of the conjunctiva mark the greatest infiltration and diminution of the blood supply. The discharges on the surface of the conjunctiva often assume the form of thin, yellowish, reticulated patches of varying size. In some instances, thick opaque membranes are formed which are so coherent that they can be stripped off with difficulty in large pieces from the inner surface of the lids. The forcible removal of this structure may, however, cause considerable bleeding. The conjunctiva thus denuded does not present a red, succulent, villous surface like that seen in purulent ophthalmia, but instead, another layer of this yellowish substance.

The course of the disease may be very mild, and therefore not very dangerous, if it occurs secondarily to diphtheria, but, on the other hand, it may occur as a primary affection and run a more serious course. It may also be secondary to purulent ophthalmia, the latter assuming a diphtheritic character.

The cornea is very apt to be affected early in the course of the disease, in which case it breaks down rapidly and is partially or totally destroyed. When the cornea becomes implicated, its luster is diminished to a certain degree, its surface is faintly clouded, and the epithelial layer somewhat abraded. The dense, hard, infiltrated conjunctiva pressing upon the cornea and upon the blood-vessels supplying it, greatly impairs its nutrition, and necrosis of this structure may very shortly ensue. The sloughing of the lids is very apt to cause adhesions between them and the eyeball, producing the condition known as symblepharon, which will presently be described.

Cases have been reported in which there was very little infiltration of the eyelids, the symptoms, in the main, being those of catarrhal conjunctivitis with a slight sanious discharge.

Diagnosis.—The extreme rigidity of the lids, with the same amount of swelling as in other diseases of the lids, and the gray patches of strangulated tissue which may coalesce and extend over the entire conjunctival surface as far as the corneal margin, are characteristic points of this disease. In *croupous conjunctivitis* the membrane is superficial, somewhat resembling the diphtheritic membrane found in pharyngeal diphtheria, while in conjunctival diphtheria there may be no membrane upon the surface, or it may be a less conspicuous symptom than the rigidity of the deeper tissues. The exudation is in the conjunctiva and not on it. If upon examination of the products under the microscope the Klebs-Löffler bacillus is found the diagnosis is certain.

Treatment.—It is of the utmost importance that the disease be promptly recognized, and treated by full injections of diphtheria antitoxin, repeated at intervals of not more than sixteen hours (Standish). The results obtained from this mode of treatment have been very satisfactory. If there is great swelling of the lids, the patches of gray, rigid infiltration small and few, and the cornea has not become involved, pledgets of cotton soaked in a 1–1,000 permanganate-of-potassium solution should be applied locally. If the patient is in a depressed condition, and the cornea shows signs of infiltration, cold applications are to be avoided, and hot applications substituted. According to some authorities, cold should never be applied in this disease, as involvement of the cornea is almost certain to take place. Eserin may be used in the

attempt to prevent corneal complication; some authorities prefer atropin for the same purpose.

Careful cleansing of the conjunctiva with an antiseptic wash (permanganate of potassium, 1–5,000) is very important and should never be neglected. In the second stage of the disease, when the secretion is free and the lids have lost their rigidity, the permanganate solution should again be used, applying it to the under surface of the lids. This solution must be employed as long as any trace of the diphtheritic membrane remains. Sir John Tweedy, of Moorfield's, recommends the use of bisulphid-of-quinin solution. A saturated solution of pyoktanin (blue) has been applied with success in this disease. The local application of the silver preparations has also been employed.

If only one eye is affected, the healthy eye should be very carefully protected against infection with a Buller's shield.

The patient's strength should be supported throughout the attack by strychnin, alcohol, and iron.

Prognosis.—The chance of saving the eye depends solely upon the *early institution of the antitoxin treatment*, and the local applications of antiseptic lotions; if it is not begun early in the course of the disease, sloughing of the cornea will certainly take place and result in blindness.

PHLYCTENULAR CONJUNCTIVITIS

SYNONYMS: *Scrofulous, strumous, pustular, lymphatic conjunctivitis or ophthalmia; Conjunctivitis eczematosa; Herpes conjunctivæ* (Stellwag).

Definition.—An inflammation of the conjunctiva usually situated on the ocular portion near or at the corneoscleral margin, characterized by one or more efflorescences called phlyctenules, and sometimes accompanied by a congested network of blood-vessels extending toward the cornea. In severe cases the palpebral conjunctiva may become involved. The cornea is generally implicated to a certain extent, and the disease is dangerous in proportion to this implication.

Etiology.—The disease depends on a scrofulous diathesis, occurring in poor and young children, very commonly in young girls, with an underlying tendency to catarrhal affections of all mucous surfaces, eczematous eruptions, and glandular enlarge-

ments. The exciting cause is undoubtedly some microörganism. While it may occur in adults, it is much commoner in children, constituting about 25 per cent of all diseases of the eye in children. When it is met with in adults there is always a history of ocular involvement in childhood.

The affection frequently makes its appearance as a sequel to one of the infectious fevers, and nearly always occurs in debilitated subjects. It is most often encountered in the children of the poor, in whom nutrition is low and whose surroundings are positively unhygienic. The dietary of these children is made up largely of tea, coffee, and similar unwholesome articles which contribute to the etiology by the nutritional disturbances they induce. It may occur in the children of the better classes, in whom these causes are apparently absent, but careful inquiry and examination will serve to disclose some underlying predisposition such as already described.

Symptoms.—The disease usually begins with irritability of the eyes, photophobia, and excessive lacrymation. Vesicular elevations make their appearance on the ocular conjunctiva, usually near the corneal margin, or on the cornea itself. The phlyctenulæ are quickly transformed into small ulcers, from which a puslike exudate, containing epithelial cells, leucocytes, and bacteria, escapes. The conjunctiva is intensely red, which redness appears at first in spots, later tending to become general, although the lesions themselves are rather isolated than diffuse. This redness disappears in a few days, the swollen tissue of the phlyctenulæ gradually returning to normal, probably by resorption. The entire attack lasts from one to four or five weeks, unless prolonged by corneal ulcer. Frequently a second attack begins before the first has terminated, so that the eye is continually in a red and painful state.

The palpebral conjunctiva appears hyperemic, the vessels being larger than normal, and there may be a slight discharge, causing the lids to be glued together in the morning.

An extension of the disease to the cornea is characterized by the appearance of one or more of the nodules advancing from the margin to the center, accompanied by a red band or fascet of blood-vessels. This gives rise to a superficial form of corneal ulceration known as fascicular keratitis. In severe cases, corneal infiltration may be induced.

The photophobia is often very severe, in fact so severe patient refuses to open his eyes even when placed in a c room.

Diagnosis.—The distribution of the hyperemia, the rence of the phlyctenulæ, or the ulcers that follow th excessive photophobia and lacrymation, and the discha symptoms which differentiate this form from other var conjunctivitis.

Treatment.—The treatment is general and local. A the severity of the ocular symptoms would indicate loc: ment above, the constitutional disturbances should rece consideration. Tea, coffee, fried foods, sweetmeats, cak dies, etc., should positively be withheld. Fresh air, daily milk in abundance, sunlight, cleanliness, etc., should be pre Calomel, gr. $\frac{1}{20}$ (0.003), should be administered twice c its antiseptic effect upon the intestinal tract. Cod-liver oi also be given internally, but is preferable when not em The syrup of the iodid of iron, quinin, and arsenic are al cated. The accompanying nasal, aural, or dermal co should be promptly treated.

Locally the eye should be placed at rest by the weari protective bandage or dark glasses. Irrigation of the con should be performed frequently with the ordinary boric-ac tion (gr. x (0.6 gm.) to the ounce). The employment dicaments in ointments is of especial value in this connec follows (*if photophobia is marked*):

℞	Eserinæ sulphatis	gr. $\frac{1}{4}$;	0.015
	Hydrargyri oxidi flavi	gr. $\frac{1}{8}$–1;	0.008
	Petrolati	ʒj;	4.000

Misce. Sig.: Apply to lids two or three times daily.

or

℞	Daturinæ sulphatis	gr. $\frac{1}{6}$;	0.010
	Hydrargyri oxidi flavi	gr. $\frac{1}{8}$;	0.008
	Petrolati	ʒj;	4.000

Misce. Sig.: Use locally.

Atropin is usually employed, but a persistence of the inten tophobia indicates eserin. Calomel should be dusted u

ulcers except when iodin is being administered internally. Cold compresses relieve the attendant pain, but should be substituted by hot compresses if there is any indication of corneal involvement.

The photophobia is often so intense that marked blepharospasm is induced which interferes greatly with the treatment. In such cases, dipping of the child's face forcibly into a basin of cold water and holding the head immersed until the lids open serves to overcome this spasm of the orbicularis muscle (Arlt). Sometimes it is so intense as to require temporary canthoplasty. The author's best results in breaking up the intense orbicularis spasm are obtained by stretching the eyelids to their utmost by the aid of lid retractors. The stretching should last from three to five minutes. This, of course, must be performed under an anesthetic. The instillation of cocain often relieves the condition by lessening the sensitiveness of the conjunctiva and cornea. The ulcerations will be greatly benefited by the application of some form of silver. Protargol, or a strong solution of silver nitrate, may be employed. Touching the phlyctenules with a mitigated stick of silver nitrate is of decided value. A decoction of poppy heads applied to the eyelids serves to relieve any attendant pain. A combination of suprarenal extract (1–1,000) and chloretone has given gratifying results in this affection by reason of its hemostatic, anesthetic, and antiseptic properties.

Prognosis.—The prognosis is favorable in most cases. Usually it undergoes involution in one to five weeks, but recurrences are frequent. Slight opacities may remain if the cornea is involved. In severe cases, perforation and its sequelæ may occur.

VERNAL CONJUNCTIVITIS

SYNONYMS: *Spring catarrh; Frühjahr's catarrh* (Saemisch); *Saemisch's disease; Phlyctæna pallida; Hypertrophie perikeratique; Conjunctivitis verrucosa; Circumcorneal hypertrophy of the conjunctiva.*

This is a somewhat infrequent affection of the conjunctiva, except at certain seasons of the year, and is rather difficult to properly name and classify, as it differs from any other known form of conjunctivitis. The term "spring catarrh," as pointed out by Allport, does not describe the disease from a pathological standpoint. It is a hyperplastic conjunctivitis. The investiga-

tions of De Schweinitz and Shumway likewise confirm this view. It is much more frequent in young individuals, and affects chiefly the male sex. The disease usually affects both eyes, but its particular characteristic is its chronic course; the disease recurs every spring and summer for a variable number of years.

Etiology.—According to Dr. Cheatham, little or nothing is known concerning the etiology of the disease. He believes that the disease is sporadic and noncontagious. The latter being true, he says he makes it of much importance to obtain a correct diagnosis, and that the bulbar form offers a better prognosis than the tarsal. His observation has been that the disease may, and often does, last for years.

Thaler has examined microscopically bits excised from a conjunctiva affected with this disease, and he finds that the epithelium takes no share in the process. The mass of the granulation is made up of fibrous tissue strands containing large membranes of lymphocytes and many mast cells. He has not found yellow elastic tissue predominating, but there is present much hyaline degeneration, and, having regard to the class of patient in whom this disease occurs, he is of the opinion that it is of the nature of a lymphadenoid disease, which frequently shows itself by enlargements of the glands and elsewhere.

Goldzieher has made similar observations with like results, and Schieck, who has contributed the last and best study of this disease, makes similar observations.

Pascheff has made a clinical and pathological study of "spring catarrh" based on 93 cases and illustrated by microphotographs. His findings and conclusions are those recorded by previous writers. He draws especial attention to the sleepy look of many patients suffering from "spring catarrh," an appearance due to the drooping of the affected upper eyelid. He also associates the disease with the "lymphadenoid" diathesis, as revealed by hypertrophic rhinitis, enlarged tonsils, adenoids, etc. Pascheff has seen the circumcorneal thickening persist for fifteen years and the characteristic "pavement" condition of the upper lid for as long as nineteen years.

Symptoms.—The disease, which makes its appearance with the first warm days of spring, is characterized by excessive itching. The conjunctiva, which is slightly swollen, has a bluish-

pink tint, and that of the tarsus is covered with broad, flattened papillæ, while brownish, uneven, hard nodules of gelatinous appearance grow upon the bulbar conjunctiva from the limbus of the inner and outer side of the cornea. These changes in the bulbar conjunctiva are not so constantly present as those in the tarsal conjunctiva. No pain is experienced, although the itching is intolerable, and photophobia causes the patient a considerable amount of distress.

Unless carefully observed, vernal conjunctivitis may easily be confounded with the catarrhal variety, since the palpebral conjunctiva presents in the recurring stage symptoms of catarrhal conjunctivitis with slight mucous secretion. As the disease develops, the conjunctiva in the retrotarsal fold becomes grayish red, and has a flaky appearance, even after the secretions have disappeared. In some cases a mushroomlike protuberance spreads over the ocular conjunctiva, particularly on the temporal and nasal sides of the cornea.

The excessive itching of the eyeball is the most characteristic symptom, and lasts for weeks. The effort to gain relief by constant rubbing increases the injection, the swollen conjunctiva assuming a bluish-pink tint around the cornea, and it is with difficulty that the eyelids can be kept open. This condition lasts as long as the warm weather continues, but, like hay fever, rapidly disappears when there is a drop in the temperature to about 65°. The author recalls a patient who obtained instant relief by going into a cold-storage warehouse; however, this relief only lasted while under the influence of the cold atmosphere. Patients with hay fever obtain the same temporary benefit. It is astonishing to note the disappearance of the symptoms during a period of cool weather. The objective findings in this disease are much the same in winter as in summer, but the subjective symptoms entirely disappear.

Treatment.—No plan of medical treatment, either general or local, that can be relied on to cure the affection, has as yet been devised. The internal administration of Fowler's solution of the arsenite of potash, 5 drops three times daily in water, has been highly recommended. Local applications of astringents sometimes diminish the discomfort. The application of boroglycerid (50-per-cent solution) every hour during the day, and the lotion

at night, usually gives relief to the patient during the hot weather. Randolph reports the best results from an ointment of salicylic acid in lanolin, 2 to 15 per cent, rubbed well into the conjunctiva daily, preceded by the instillation of cocain for its anesthetic effect.

Among local remedies, one which has produced the most relief is the following ichthyol prescription:

℞ Hydrargyri oxidi flavi, Ichthyoli,	....āā	gr. $\frac{1}{8}$;	0.008
Petrolati	....	ʒj;	4.000

Misce. Sig.: Use locally.

This is followed by applications of chinosol (1–2,000), applied three or four times daily. Suprarenal extract with chloretone often affords temporary benefit.

The author has obtained the best results from the grattage operation in cases of this kind. *It should always be performed,* even in patients of four years of age, as soon as the diagnosis is confirmed. The operation is performed by the author as follows: The upper eyelid is grasped along its margin by Darier forceps, and, the edge being turned upon itself, the lid is everted until the retrotarsal fold is brought into view. A horn spatula should be inserted beneath the lid to protect the cornea. The exposed part is first thoroughly scarified with a three-bladed scalpel. The granular tissue is then scrubbed with a toothbrush which has been steeped in a corrosive-sublimate (1–500) solution just before being used. Immediately after scrubbing, the part is washed with a solution of the same strength. Another portion of the lid is now unrolled, and the scarifying and scrubbing and washing repeated until the whole conjunctival surface of the eyelid has been subjected to the treatment. If the lower lid is involved, it should be treated in exactly the same way. I have followed this treatment in 12 cases; in 10 cases the disease had not existed for more than five years; in these cases the cure was permanent. Quinin internally in full doses (5 to 10 grains three times daily) is of value.

Prognosis.—The prognosis, as to ultimate recovery without permanent damage to the eye, is very good, although the duration

of the attack cannot be foretold, as there is a liability to recurrence of the trouble year after year.

One patient, in my own experience, had a recurrence of the disease for eight consecutive years. The *grattage operation* was performed, and since then there has been no recurrence of the trouble. Five other cases were similarly treated, and with the same gratifying results.

In the cases refusing the radical cure we must content ourselves with the acetic acid wash (acid acetic, gtt. x; aq. destil., ℥iv; sig., 2 drops in each eye three times daily). To this solution 5 gtts. are added each day until a smarting sensation is produced.

FOLLICULAR CONJUNCTIVITIS

SYNONYMS: *Folliculosis; Conjunctivitis follicularis; Follicular ophthalmia.*

Follicular conjunctivitis is characterized by the presence of small, round, translucent elevations in the conjunctiva, the size of a pin's head or sago grains, situated chiefly in the fornix and generally arranged in a row parallel to the margin of the lid. They also appear in clusters in the retrotarsal folds, and even extend into the *cul-de-sac*.

Etiology.—The affection is found in young patients, and is accompanied with slight photophobia and painful sensations, which prevent a continuance of close study. This disease often lasts for months, and as it disappears the mucous membrane assumes its normal state. It is the *conjunctivitis* which appears periodically in large schools, asylums, or prisons, and is infectious. A child having this disease may communicate the secretion to another by means of towels, wash basins, etc. Whenever detected the child should be isolated, or else the whole school or institute may become infected.

Symptoms.—The symptoms are the same as in ordinary catarrhal conjunctivitis. The distinguishing feature is the presence of the hypertrophied lymph follicles, which are most abundant upon the lower lid and which show no tendency toward ulceration and subsequent cicatrization.

Treatment.—As soon as a patient is found suffering with the disease he should be isolated, and the eyes thoroughly irrigated with the formula of boric acid and hydrastin described under

ophthalmia neonatorum, and a mild solution of silver nitrate, 1 grain to 1 ounce, applied once daily. The edges of the lids should be anointed at night with the following ointment:

℞ Hydrargyri oxidi flavi, }
Ichthyoli, } .... āā gr. $\frac{1}{8}$; 0.008
Petrolati .... ʒj; 4.000
Misce. Sig.: Apply to eyelids.

Rubbing dry boric acid into the enlarged follicles, or touching the everted lid with copper sulphate crayons (a common practice among the Egyptian physicians 1500 B.C.), or alum crayons, and washing away the excess with sterile water or boric-acid lotions, are efficacious measures. This latter operation may be repeated two or three times a week.

The complications that may arise, if the disease is not cut short by prompt measures, are true trachoma and pannus, with aphthous ulcers, which will form along the corneoscleral margin of the conjunctiva in neglected cases. Among the more recent remedies which have proved beneficial is protargol (5-per-cent solution) dropped into the eye four times daily.

Grattage has been performed with satisfactory results in some cases of follicular conjunctivitis, which proved intractable under other treatment. Some patients, however, will not give their consent to a surgical operation, and in these cases medicinal treatment should be instituted.

For those patients who will not undergo so radical an operation as grattage, but desire to obtain a quicker cure than can be effected by simple medical treatment, the following operation may be performed:

A Knapp's roller forceps is inserted well back in the *cul-de-sac*, closed, and with firm pressure pulled away from the eye. This breaks down the follicles and expresses their contents. Unless the retrotarsal fold is thoroughly cleansed, a cure will not be effected. This space can best be reached by rolling the eyelid around the Darier forceps.

GRANULAR CONJUNCTIVITIS

SYNONYMS: *Trachoma; Egyptian ophthalmia; Military ophthalmia; Granular lids; Conjunctivitis trachomatosa.*

Definition.—A contagious, inflammatory disease of the palpebral conjunctiva, characterized by increased thickening and vascularity, and the formation of granular elevations, or lymphoid infiltrations which undergo ulceration and subsequent cicatrization.

Etiology.—Granular conjunctivitis is of infectious origin. Sattler, v. Michel, Raehlmann, and others have described diplococci, Shongolowicz and L. Müller bacilli, but none of these have proven worthy of acceptation.[1] Muttermilch doubts the existence of a specific organism. The recent studies of Greeff, Prowazek, Halberstädter, Frosch, and Clausen seem to have led up to the cause of trachoma. Halberstädter and Prowazek succeeded in finding the specific cause after inoculations upon anthropoid apes. They have, however, not yet been able to give the so-called *trachoma bodies* a definite classification. They are difficult to demonstrate, and are believed to occupy a position morphologically between bacteria and protozoa. The technic is as follows:

Fresh cases are the best—negative in the cicatricial stage. By means of a platino-iridium instrument, preferably one having a "scraping" surface, the secretion is taken from the palpebral conjunctiva, and if possible some of the superficial epithelium as well (gently scraped away), and then transferred to cover-glasses. (1) Dry in air. (2) Fix for a quarter of an hour in absolute alcohol.

Prepare the following solutions:

1. 2.5 cm. 1-per-cent French eosin solution to 500 c.c. of distilled water.
2. Azur I (1 : 1,000).
3. Azur II (0.8 : 1,000).

Mix 12 parts No. 1, 3 parts No. 2, 3 parts No. 3. Filter carefully. Prepare freshly whenever required.

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[1] For an exhaustive description of the search for the cause of trachoma the student is referred to the work of Cazalis ("Étude bactériologique sur la conjunctivite granuleuse," 1895.)

Immerse cover-glass preparations for six hours. Wash with water. Dry between blotting paper. Mount in cedar oil.

This is the best stain. They can be stained with methylene blue and carbol fuchsin, but not very distinctly. They are gram-negative. (See chapter on Laboratory Technic.)

The disease is nearly always acquired by contact with the secretion, but cases occasionally arise spontaneously. Debilitated individuals and those with chronic obstinate conjunctivitis (Boldt) seem more disposed than others. It is found most frequently in barracks, asylums, almshouses, etc., the inhabitants of which are careless in the use of towels, handkerchiefs, and similar personal articles. It is particularly common among immigrants, especially the Jews. The American negro seems comparatively immune to the affection. In certain countries, such as Egypt, Arabia, and eastern Europe, it is extremely prevalent. High altitudes usually seem inimical to it, as it is most common in low countries. According to Boldt, however, trachoma forms 8 per cent of all eye diseases in the Caucasus, at an altitude of 2,000 meters. On account of the prevalence of the disease among the soldiers of Napoleon, the term "military conjunctivitis" has been applied as synonymous of granular conjunctivitis. There is no such disease as this term implies as far as its occurrence specifically among soldiers is concerned. Indeed, the disease was recognized by the Greeks two thousand years ago (Hirschberg). Equally confusing from a standpoint of systematic nomenclature is the term Egyptian ophthalmia. Trachoma has an extensive geographical distribution. It has been endemic as well as pandemic, and while it occurs less frequently in some countries than in others, it is sporadic everywhere, although less severe than formerly. The scrofulous diathesis is a predisposing cause. The disease often follows a purulent ophthalmia.

Pathology.—The term "granulations," considered by Vetsch (1807) to be a characteristic description of the chief pathological factor of the disease, is still employed. Whatever the variety of trachoma may be, the trachoma follicle is present. Whether these lymph follicles described by Bendz are present in the normal conjunctiva (Baumgarten, Stöhr) or pathological (Waldeyer) is still a subject of debate. However, it has not yet been accomplished to histologically differentiate *follicular* from

granular conjunctivitis, unless the newly described findings in trachoma described above prove to be pathognomonic.

Symptoms.—The disease is usually chronic, although occasionally acute cases may be observed in which there are marked inflammatory symptoms and profuse purulent secretion, the acuity of certain attacks being probably due to a concomitant acute conjunctivitis, or an exacerbation of the symptoms as the result of freshly developing follicles. These cases resemble purulent conjunctivitis, and often the diagnosis must be withheld until the granulations are visible. It is usually bilateral.

In quite a number of cases the initial course of the disease is so insidious that the patient is not aware of its presence until the case is quite well developed. The changes in the palpebral conjunctiva are slowly progressive; the membrane becomes thickened, vascular, and roughened by firm hemispherical elevations. This change usually takes place first in the upper lid, later extending to the lower lid, giving rise to the growth of considerable organized new tissue in the deep parts of the conjunctiva. Externally, edema and vascularity of the lids is noticeable, while the ocular conjunctiva is congested and has an angry appearance; slight photophobia and lacrymation are present, and a "gritty" feeling, due to the roughened condition of the palpebral conjunctiva, is experienced by the patient. If the lids be everted in the early stages of the affection, the surface is found covered with small granular bodies, which look very much like small sago grains, scattered or massed together (*follicular trachoma*), constituting the chief feature of the clinical picture. In the later stages this tissue is partly absorbed and partly converted into dense, tendinous scar tissue, which, by its shrinking very often, occasions considerable annoyance and deformities of the lids. In all cases the folds and ocular surfaces are very greatly irritated by the roughened surface, producing a host of resultant troubles by mere friction. In many cases the inflammation is intense, the discharge excessive, the cornea becomes involved early, and only prompt and vigorous treatment can prevent complete blindness. A mixed infection may exist with the trachomatous process. Koch (*Wiener med. Woch.*, 1883) in Egypt found both the gonococcus and what is now classified as the Koch-Weeks bacillus in the discharge from the conjunctiva of trachoma cases. The

trachoma granules in some cases are deeply imbedded beneath the thickened opaque conjunctiva, or in the masses of fibrous tissue that have developed in the lid, so that they can hardly be seen, if at all (*papillary trachoma*). The lid becomes swollen, and drops by reason of its increased weight. The palpebral fissure becomes more narrow than normal. There is always a mucopurulent discharge, considerable in amount in acute cases and scanty in those of long duration. A demonstrable coexistence of the described varieties is known as *mixed trachoma*.

Diagnosis.—The diagnosis can be quite easily established by the presence of the small trachoma granules on the lids, and a drooping of the upper lid which is almost characteristic. The disease may be mistaken for follicular catarrh when the granules are distributed and confined to the retrotarsal fold. In the early stages of the disease the changes in the conjunctiva, together with the absence of marked discomfort, are quite characteristic of trachoma.

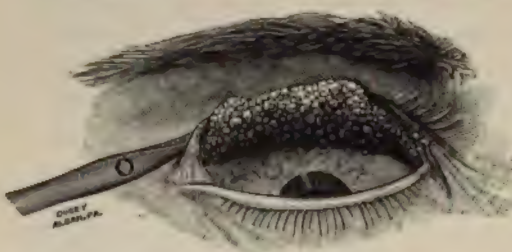

FIG. 60.—TRACHOMA.
Retrotarsal fold of conjunctiva exposed, showing granulations.

Treatment.—The treatment is directed to the reduction and absorption of the granular formation, this being best brought about by the application of astringents, frequently applied. Strong caustics or astringents may also be used. Weak solutions of silver nitrate are, however, preferred by some ophthalmic surgeons to any other astringents. Protargol, argyrol, and similar silver preparations have been highly recommended. Equal parts of boroglycerin and glycerin are also efficacious. The daily application of alum or copper sulphate crayons to the everted lids is the principal indication in the less malignant types. Some authorities claim that recovery is hastened by mechanically pressing out the granular formations, and Knapp and Gifford have invented forceps for this purpose. It may also be performed with the thumb nails. The process is, however, somewhat painful, and general anesthesia should be employed if an extensive area is thus treated. For obstinate cases the following is of value:

℞	Cupri sulphatis	gr. j;	0.06
	Acidi salicylici	gr. ij;	0.13
	Cocainæ hydrochloridi	gr. iij;	0.20
	Petrolati	℥j;	30.00

Misce. Sig.: Use upon eyelids one or more times daily.

This formula is beneficial in all stages of the disease.

If sulphate-of-copper crayons are used they should be delicately applied to the granular surface, and followed by irrigation. The growth of the granules will generally be cut short by this procedure. The dusting of powders such as calomel (provided no form of iodin is being administered internally), aristol, boric acid, etc., well rubbed into the follicles (Bickerton), may also be employed.

Since the disease is highly contagious, it is needless to emphasize the constant need of extreme cleanliness, as well as attention to constitutional treatment and hygiene.

It is sometimes possible to hasten the cure by everting the lid and excising the granular formation with scissors, or by scraping tissue down to the basement membrane with scoop or scalpel.[1]

Grattage.—Much success has attended the grattage operation in the treatment of trachoma. In the author's experience, it gives the quickest and most permanent results.

The operation is performed as follows: The upper eyelid is grasped along its margin by Darier's forceps, and the edge being turned upon itself, the lid is everted until the retrotarsal fold is brought into view. A horn spatula should be inserted beneath the lid to protect the cornea. The exposed part is first thoroughly scarified with a three-bladed scalpel. The granular tissue is then scrubbed with a toothbrush which has been steeped in a corrosive-sublimate (1–500) solution just before being used. Immediately

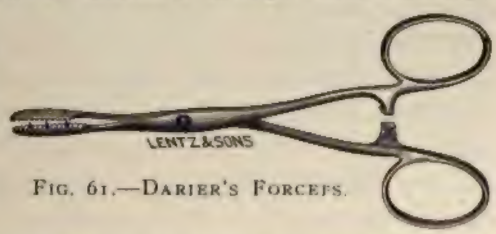

FIG. 61.—DARIER'S FORCEPS.

[1] The author practiced this operation as early as 1885. See Fox and Gould's "Diseases of the Eye," Quiz-Compends Series.

after scrubbing, the part is washed with a solution of the same strength. Another portion of the lid is now unrolled, and the scarifying, scrubbing, and washing repeated, until the whole eyelid has been subjected to the treatment. If the lower lid is involved in the trachomatous process, it should be treated in exactly the same way.

In the soft gelatinous variety of granulations the author has found that by using ordinary gauze sponges he has been able to smooth down the elevations and clean off the conjunctiva of both lids, leaving it perfectly smooth, so that in a few days all evidences of the trachoma have disappeared. In a case which recently came under his care, in which there was implication of the cornea with pannus, the blood-vessels over the pannus disappeared at the end of a week, with very little or no reaction. The lotion described under Hordeolum is applied over the lids

FIG. 62.—DARIER'S THREE-BLADED SCARIFIER.

in addition to cold compresses day and night. The eyelids can usually be opened in twenty-four hours without pain or annoyance. Dr. Coover, of Denver, uses sandpaper with much success in similar cases.

Frequently a Burow's operation, cutting through the cartilage from the inner to the outer canthus, performed at the same time aids the grattage by expanding the eyelids. In trachoma the swollen condition of the conjunctiva and cartilage prevents the free movement of the eyeball, and by exerting pressure produces pain, and aids in the formation of pannus. Slitting the cartilage (Burow's Operation (*q. v.*)) relieves this pressure and its consequent danger.

There is very little reaction to this apparently harsh procedure. The patient is put to bed and the lotion described under Hordeolum applied. The eye pads are kept saturated for two or three days, and if the operation has been properly carried out the results are exceedingly gratifying. It rarely happens that the operation must be repeated more than once on the same patient.

The French method consists in everting the eyelid after

twenty-four hours and again applying the corrosive-sublimate (1–500) solution to the conjunctival surface. This procedure is very painful and unnecessary.

Within the past year a number of foreign observers, particularly Mayou, Stephenson, and Walsh, have used the X-ray in the treatment of this disease with gratifying results. The galvanocautery has also been employed, but is of most service in isolated granules.

Electrolysis has been employed by a number of ophthalmic surgeons for the removal of the granulations of trachoma. The method employed by T. D. Myers, Philadelphia, for this purpose is probably the best, as it is not followed by cicatrices and very little reaction. A 30-cell galvanic battery is employed together

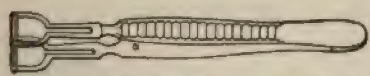

FIG. 62*a*.—KNAPP'S TRACHOMA FORCEPS.

with a reliable milliampèremeter. A current of 1½ to 2 milliampères is usually sufficient. The lids should be everted and a 4-per-cent solution of cocain be instilled. The needle, attached to the negative pole, is inserted into the granulations, after which the positive pole is placed in contact with the back of the neck. The vessels supplying the granulations should be attacked when possible. The effect of the current is shown by the coagulated material that collects about the needle. The number of punctures made at a single sitting is seldom more than four or five. For large granulations a wire ring of the same thickness as the needle is employed. The *débris* should be removed by irrigation by means of boric-acid solution.

Sequelæ of Trachoma.—The troublesome sequelæ of trachoma are all natural consequences of the friction of the roughened palpebral conjunctivæ. As a rule, mere removal of the causal condition affects their disappearance. In certain cases, however, this is unfortunately not true. The cicatrices following the absorption of the granulations may so "pucker" the conjunctiva as to draw the edge of the lid inward, producing trichiasis or entropion; in either case the friction is greater than that directly due to the trachoma. The most frequent and trouble-

some sequel of trachoma is pannus. Corneal ulcers, staphyloma, symblepharon, ectropion, and xerosis may also occur.

PANNUS

SYNONYMS: *Trachomatous keratitis; Superficial keratitis.*

Primarily it is an affection of the corneal epithelium, but since the deeper layers of the cornea become involved, as the result of trachoma, it may be discussed here. It is characterized by a subepithelial infiltration of cells, and distention of capillaries, forming a fine tortuous network extending from the limbus conjunctivæ toward the center of the cornea.

It may be due to the irritation of the granules against the cornea or to the extension of the trachomatous process to the cornea. It is usually due to mechanical irritation.

Symptoms.—Pannus does not arise in the course of trachoma until the latter disease is well established, and there is marked roughening of the inner surface of the eyelids, the upper eyelid being usually the first one to be affected. It generally occurs in those cases in which, on account of the swelling of the eyelids, or for other reasons, the eyes are not kept sufficiently or fully open. Abrasions of the superficial layer of the cornea are quite frequent.

FIG. 63.—PANNUS.

It may develop rapidly, with intense hyperemia, causing severe photophobia and practically blindness in a few weeks. If trachoma has given rise to cicatricial scars and left the lids markedly deformed, and especially if they press upon the cornea with permanent narrowing of the palpebral fissure, the pannus may remain after the trachoma has disappeared.

Diagnosis.—Pannus is distinguished by innumerable small blood-vessels running down over the cornea, extending to the pupil. Sometimes the whole cornea becomes invaded by these blood-vessels, changing the corneal epithelium to such an extent that vision is practically lost. In such cases it is very difficult to clear the cornea entirely even after the pannus disappears, a translucent haze, due to the morbid changes that have taken place in the epithelial layer of the cornea, persisting. The appearance of the vessels in pannus is sufficiently characteristic to differentiate it from pterygium.

Treatment.—Pannus generally disappears when the conjunctiva and lids are restored as nearly as possible to their normal condition. If this does not occur, peridectomy is advised, this operation usually being successful. The term *peritomy*, or syndectomy (Fig. 65), is the term applied to an incision of the conjunctiva at the corneal limbus, and *peridectomy* (Fig. 64) is used to designate the excision of a strip of the conjunctiva 5 mm. or more wide surrounding the cornea, first performed by Furnari, of Paris, in 1842. The latter is but an elaboration of the former operation. It is performed as follows:

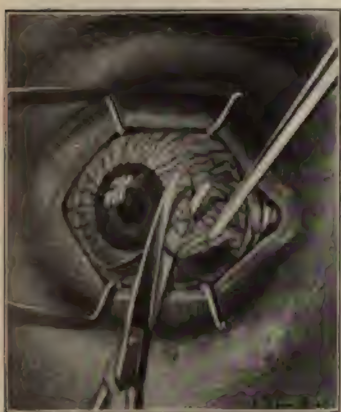

Fig. 64.—Peridectomy.

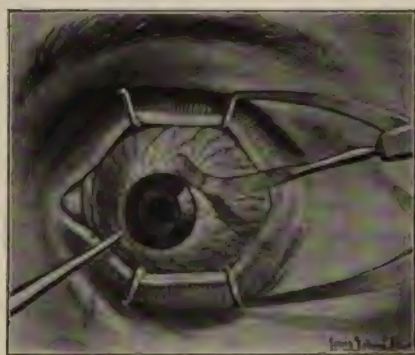

Fig. 65.—Peritomy.

The eyelids are held apart by a speculum and several instillations of cocain made in order to anesthetize the conjunctiva. A fold of conjunctiva near the cornea is grasped by the fixation forceps, and divided by scissors. For partial pannus a band of circumcorneal conjunctiva about 5 mm. wide is dissected on the

side of the engorged vessel. If the pannus be general, a complete circular zone must be cut away, including the subconjunctival tissue to the sclera, in order to form a dike of cicatricial tissue against the convergent vessels. In cases of pronounced pannus, a circular incision of the corneal blood-vessels by means of a Beer knife is necessary. The ordinary peritomy operation consists merely in dividing the conjunctiva at the corneal limbus for its entire circumference.

The author has found it advisable at times to defer peritomy or peridectomy for a week or two, as the grattage operation frequently acts beneficially upon the pannus.

Although immediately after a peridectomy it appears that matters have been made worse, a satisfactory outcome is the rule. Energetic massage of the eyelids sometimes seems to give relief. Photophobia and pain are usually much lessened by instillations of atropin, or one of the other mydriatics. In 210 operations of this character performed by the author within the last three years the results have been most gratifying. In all of these cases the progress of the affection was stayed. The excised portion of conjunctiva was replaced by white scar tissue and the transparency of the cornea was wonderfully improved. The operation has no substitute and deserves proper recognition by ophthalmic surgeons, as its results are superior to other forms of treatment in the condition mentioned and it is productive of no ill effects.

An artificial purulent ophthalmia, produced by the instillation of an infusion of jequirity seed (3 parts pulverized seed in 500 parts water) is sometimes employed to relieve the corneal irritation and cloudiness. A more recent treatment is that advised by Dr. Carl Hood (1903), in which jequiritol or jequiritol serum is employed. The inflammation thus produced is allowed to run its natural course, and, if the treatment is successful, the cornea should lose its cloudiness within about two weeks' time after the inflammation has begun. The advantages of this procedure are certainly very doubtful, since it is not possible to regulate the inflammation, but it is infinitely preferable to the pernicious practice of inoculating the eye with gonorrheal pus, which formerly had a certain vogue. If a syndectomy or peritomy has been performed this procedure becomes less dangerous.

Prognosis.—Absolute recovery never follows a severe case of pannus, although there may be restoration of good vision.

TUBERCULAR CONJUNCTIVITIS

Tuberculosis affecting the conjunctiva has been described, and as a rule involves but one eye. It presents a clinical appearance not unlike that of trachoma, but the ulcers are of greater size. Other forms of tuberculosis nearly always can be demonstrated elsewhere in the body.

The *treatment* is largely supportive in character. The local lesions should be destroyed when possible. The local treatment of trachoma is applicable also in this disease. The outlook is unfavorable. In a case of tubercular conjunctivitis recently reported by Sidney Stephenson a cure was effected by the X-ray.

PARINAUD'S CONJUNCTIVITIS

An inflammatory condition of the conjunctiva resembling acute trachoma, characterized by large polypoid granulations and ulcerations. It attacks but one eye at a time, and is attended by swelling and edema of the lids and a mucopurulent discharge. Adjacent lymphatic glands are usually enlarged, and may suppurate. There is always more or less constitutional disturbance. The duration varies from a few weeks to several months.

Fig. 66.—Parinaud's Conjunctivitis.

The disease was supposed by Parinaud, who first described it in 1889, to be due to animals, as in some of his cases the patients were butchers, but this has not yet been substantiated. The literature on the subject and a table of published cases can be found in the article by Verhoeff and Derby (*Arch. of Ophthalmology*, No. 33, 4, p. 386, 1904).

The rarity of the condition has prevented the mapping out of any specific *treatment*, but the employment of mild antiseptic and sedative eye lotions and measures tending toward the destruction of the granulations has been of value in most cases. Recurrences are frequent.

LITHIASIS OF THE CONJUNCTIVA

Lithiasis of the conjunctiva is due to the inspissated contents of the Meibomian glands becoming calcified from the deposition of lime salts. They appear as small, light-yellow concretions, and can frequently be seen on the everted lids of elderly people.

Treatment.—Each of the deposited concretions should be removed with a needle. (Ball advises a cataract needle, and Fuchs recommends first making an incision in the conjunctiva.)

CONJUNCTIVITIS NODOSA

SYNONYMS: *Ophthalmia nodosa* (Saemisch).

This affection of the conjunctiva is an irritation caused by caterpillar hairs, usually of the species Lasiocampa, or Bombyx (*B. rubi, B. pina*), Liparis (*L. monacha, L. dispar*). The disease is characterized by nodular formations somewhat resembling tubercles (pseudo-tuberculosis of the conjunctiva) [Wagenmann]. It was first described by Pagenstecher (1883).

The cornea and iris may become involved, and even the choroid (Reis). Photophobia, lacrymation, and intense conjunctivitis are prominent symptoms. The hairs are generally demonstrable upon microscopic examination within the nodules, and are surrounded by giant cells and round-cell infiltration.

Treatment.—The treatment consists of excision of the nodules.

CONJUNCTIVITIS PETRIFICANS

This is a rare disease described by Leber in the report of the Ophthalmological Society of Heidelberg in 1895, and is characterized by the appearance on the conjunctiva of white opaque spots involving both the palpebral and bulbar conjunctiva. The spots vary in size, are uneven and very hard, due to lime salts. New crops appear while others are disappearing. The inflam-

matory symptoms are slight, but the whole process may last for a long period. Symblepharon may occur.

PTERYGIUM

Definition.—A vascular thickening and hypertrophy of the ocular conjunctiva and subconjunctival tissue often encroaching upon the cornea.

The growth is roughly triangular in shape, with the apex pointing toward the center of the cornea, and the base at the corneal margin—usually on the nasal side. The condition most frequently occurs on but one side of the eye, but several cases in which a pterygium has existed at the inner and outer canthus of the same eye have been encountered by the author.

Etiology.—The condition in all probability arises from the constant irritation of dust or other foreign particles that may gain an entrance into the conjunctiva, and is common in individuals exposed to these influences, such as laborers, sailors, cooks, bricklayers, etc. It constitutes about 7 per cent of all ocular affections. It is infrequent in cities, and seldom occurs in persons who lead sedentary lives exclusively. Traumatism and ulcers of the cornea occasionally act as factors in its production. Pinguecula frequently precedes pterygium, and is considered by Fuchs as its cause. Chacon (Mexico) regards pterygium as an evidence of alcoholism, particularly in the natives of Mexico.

Symptoms.—For a long period the presence of the conjunctival growth is attended by no subjective symptoms. It, however, tends to progress slowly but steadily. In the less serious forms it may remain stationary without encroaching upon the pupillary area. In the progressive types the conjunctiva forming the superficial layer of the pterygium is quite vascular and supported by a thickened mass of subconjunctival tissue, the vascularity and thickening extending upon the sclera to the region of the caruncle.

The vascularity and prominence of the pterygium is only marked during the period of growth; at the later stages the growth undergoes partial atrophy, becomes pallid, and loses its vascularity.

The pterygium, except its apex, is loosely attached to the cornea, which is usually normal. The sclerotic portion is also

loosely attached. A pseudo-pterygium is often formed as the result of burns or other forms of traumatism to the eye, but is firmly attached to the underlying tissues, and is thus distinguished from the true variety.

This growth does not often give rise to discomfort so long as it does not encroach upon the pupillary region of the cornea, but it is unsightly from an esthetic standpoint.

Sight is interfered with if the pterygium encroaches upon the pupillary region. If the growth be very extensive, the movements of the eyeball may be interfered with, thus causing diplopia.

The distortion of the cornea by the presence of the growth induces astigmatism of varying degrees, which also lessens visual acuity unless corrected.

Treatment.—The presence of a small and nonprogressive pterygium in the absence of subjective symptoms contraindicates any interference. If the growth is progressing and there is danger of the pupillary area being obscured by it within a very short period, its removal should be advised. Removal of a pterygium may be accomplished by electricity or by a surgical operation. The electric current may be employed in electrolysis or in the galvano-cautery, and is best adapted for the removal of small growths. After such treatment the eye should be placed at rest and bandaged. Antiseptic and astringent eye lotions should be employed to combat any tendency toward inflammation.

Operations.—There are at present three operations in vogue —excision, ligation, and transplantation.

Excision consists in removal of the entire growth with the application of the cautery to its corneal attachment and suturing of the edges of the conjunctival wound. This method has been superseded largely by the operation of transplantation.

Ligation consists in ligating the pterygium near the sclerocorneal margin, and also near the base of the growth. In this way a large part of the mass is thus strangulated and may be removed in a few days. The ligatures should be passed by needles, and after having been cut, the thread is tied as near the base and apex of the pterygium as possible.

Transplantation is, in the author's opinion, the best operation

for the relief of this condition, and performed in the following manner has given most gratifying results: An incision is made in the conjunctiva above and below the growth, making a pocket which extends to the insertion of the inferior rectus muscle. The pterygium is then separated from the eyeball with scissors, leaving, however, the corneal attachment intact. Two needles are threaded on one strand of silk, and one of them is passed through the corneal end of the pterygium from the upper side downward. The second needle is passed in like manner, but it is brought out upward, leaving enough tissue between the two threads to hold it. With the strabismus hook the pterygium is separated from its corneal attachment (Prince), and then turned downward into the new-made *cul-de-sac*. The needles, one at a time, are passed through the conjunctiva near the insertion of the inferior rectus muscle, bring-

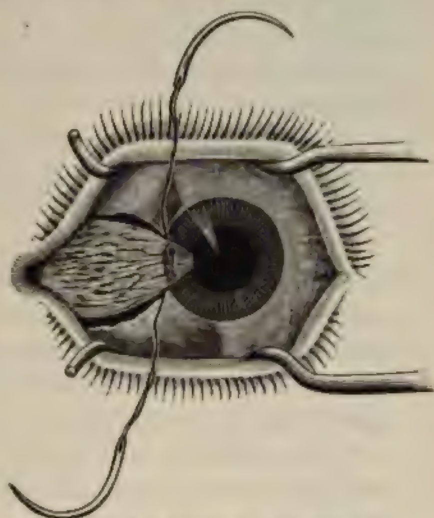

FIG. 67.—PTERYGIUM TRANSPLANTATION, *a*.

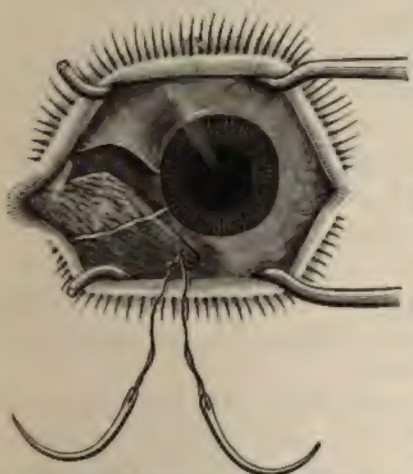

FIG. 68.—PTERYGIUM TRANSPLANTATION, *b*.

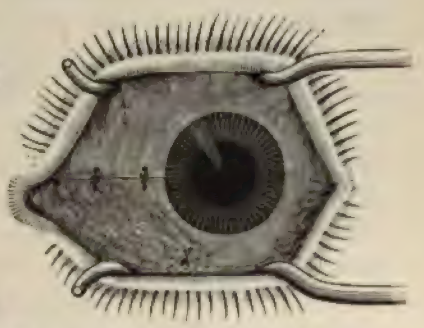

FIG. 69.—PTERYGIUM TRANSPLANTATION, *c*.

ing the head of the growth almost in contact with the muscle and holding it in place by the silk thread, which is tied. This brings the raw surface of the pterygium against the raw surfaces of the eyeball. The edges of the conjunctiva are brought over the pterygium by two or three stitches, and, while there is some puckering of tissue in the caruncular space at first, it usually disappears.

The after-dressing is the same as that applied in the ordinary conjunctival or strabismus operation. The stitches are removed after four or five days.

The advantage of transplantation is that the pterygium rarely develops again after this operation; if it should develop, however, the parts are left in a more favorable condition for a second operation. If excision be performed, the loss of tissue makes a second operation more difficult, and more liable to cause impairment of the ocular movements.

The author has also performed McReynold's operation for pterygium on several occasions, with satisfactory results. This consists essentially in dividing the pterygium close to its apex; dividing the conjunctiva and subconjunctival tissue along the lower margin of the growth and tucking the pterygium into the flap thus made by means of needles.

Other operations have been devised from time to time, and each has its advantages in selected cases. An operation of more or less popularity among ophthalmic surgeons consists in removing the growth from the cornea with as little traumatism as possible by grasping the central portion with fixation forceps and dissecting it from the cornea by means of a Beer knife toward its base. The apex of the growth is then turned over toward the base and fastened there by sutures. The conjunctiva is united over the area from which the growth has been removed. This operation is known as subinvolution.

Occasionally the ligature is employed in conjunction with excision in the following manner: The growth is loosened from the cornea by a strabismus hook or a Beer knife and separated from the adjacent conjunctiva by a small pair of scissors. A ligature is then thrown around the growth as near as possible to its base and tied. The edges of the conjunctiva are approximated by sutures, and the knot over the base of the pterygium is examined

and made more tight if necessary. The growth is afterward severed near the knot by scissors.

Knapp's transplantation operation is performed by splitting the pterygium in its long axis from the apex to the base after dividing its corneal attachment. The flaps thus made are transplanted into the corresponding conjunctival pocket (made by free dissection) and fixed by sutures. The edges of the conjunctiva should then be sutured together. The original operation was intended to transplant the entire growth in the lower conjunctival pocket, but the disfigurement necessitated the subsequent modification of splitting the growth.

Hotz has suggested excision of the entire growth and covering the denuded area with a Thiersch flap of mucous membrane.

Recurrences of the growth are not uncommon, and are more dense than the original. They usually reappear along the line of the conjunctival union, and in order to deflect the recurrence of the pterygia from the cornea, C. M. Hobby (*American Journal of Ophthalmology*, St. Louis, 1888–94) has devised a very ingenious operation.

The conjunctiva is incised along the upper margin of the pterygium as shown by the dotted line (*a–d*). A vertical in-

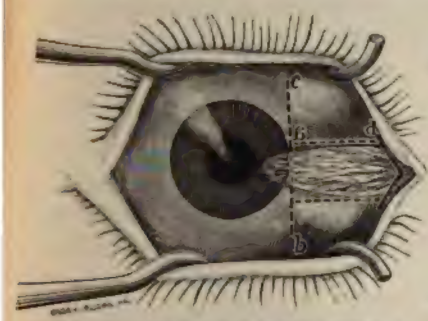

FIG. 70.—HOBBY'S OPERATION, *a*.

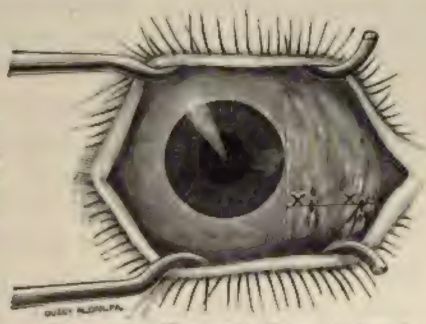

FIG. 71.—HOBBY'S OPERATION, *b*.

cision (*a–c*) is made, extending from the margin of the cornea at right angles to the first. The pterygium is separated from the cornea and the vertical incision is prolonged a trifle lower than the inferior margin of the cornea (*b*). An incision is then made along the lower border of the growth to its base and followed by careful dissection and removal of the pterygium. The upper conjunctival flap should be freed from its underlying attach-

ments and brought down to be secured to the lower fold by two sutures.

The manner in which the operations of the present period for pterygium were perfected is a matter of considerable interest. In 1813 Benjamin Bell recommended and practiced scarification of the growth perpendicular to its long axis. It is more likely that this procedure was employed only in the very large growth encroaching upon the pupillary area. Scarpa, in the early part of the nineteenth century, devised an operation in which the detachment of the head was accomplished by means of forceps. The pterygium was then dissected freely from the conjunctiva in the direction of its base, which was removed concentrically to the cornea 3 to 4 mm. from its margin. Sutures were not employed. This same operation was performed by Lawrence in 1830, Wharton Jones in 1863, and Abadie in 1876. Fano was the first to complete the operation by the introduction of conjunctival sutures, although this is accorded to Arlt by Fuchs. Transfixing the neck by means of a thread, followed by cutting the corneal attachment and base of the growth, with its subsequent extirpation, was practiced by Weller in 1832 and Walton in 1853. Szokalski in 1842 passed 3 sutures through the growth in its axis in order to strangulate it, and followed this procedure by extirpation on the third day. Desmarres in 1855 detached the pterygium from the cornea and sutured it into the adjacent lower fornix of the conjunctiva. This operation was modified by Knapp and subsequently perfected by Odaiva. Galezowski, in 1880, after freeing the growth from the cornea and adjacent conjunctiva, doubled the growth upon itself so that the apex was in contact with the base, by means of a double thread that transfixed the vertex and extremities of the base, and which was then firmly tied. Prince, in 1885, accidentally detached a pterygium from the cornea by means of a strabismus hook with a successful result. This was later adopted as the proper method for relieving the corneal attachment of these growths by Prince, L. R. Dibble, and others, and subsequently a strabismus hook with a cutting edge was devised for this purpose. Pagenstecher and De Wecker detached the growth in every portion except the base, which was allowed to atrophy. The conjunctiva above and below was dissected freely, and united by sutures. Mackenzie's method

consisted in raising the growth by grasping its center with forceps and excising it by one sweep of the scissors. The ends were then neatly trimmed and the edges of the wound united by sutures. Deval modified Mackenzie's operation by passing a thread through the center of the growth in order to raise it, instead of using the forceps. Panas extirpated the growth and cauterized its point of corneal attachment by the actual cautery.

Various other operations have been devised since the introduction of cocain as a local anesthetic, all of which are modifications of those just described.

PINGUECULA

Definition.—The condition characterized by a small, yellowish elevation of subconjunctival tissue, usually appearing first on the nasal side of the cornea. It was once thought to be a deposit of fat, until pathological investigation proved this to be erroneous. A pinguecula is a hyaline degeneration of the conjunctiva associated with hypertrophy of the elastic fibers of the conjunctiva. These changes are the result of exposure to dust and other irritating influences.

At times it becomes slightly inflamed, and by its prominence causes a certain degree of disfigurement. It has no pathological significance, except that it may precede, and predispose to pterygium.

Treatment.—For the cosmetic effect excision may be performed, or it may be destroyed with the actual cautery. Usually, however, as it does not harm, it requires no treatment.

PEMPHIGUS OF THE CONJUNCTIVA

SYNONYM: *Primary shrinking of the conjunctiva.*

Pemphigus is a rather peculiar, as well as rare, disease affecting the conjunctiva. The conjunctiva loses its epithelium in spots, which later undergo cicatrization and consequent shrinking. Very rarely bullæ are formed, as in pemphigus of the skin. The whole conjunctiva may finally become obliterated, the sight lost, and the lids firmly adherent to the globe (*symblepharon totale*).

The disease generally occurs in cachectic patients who suffer

from pemphigus affecting the skin, but is also seen in rheumatic patients.

Treatment.—Hygienic measures and internal remedies are to be resorted to and relied on. The internal administration of arsenic is especially recommended in this condition. Soothing eye washes should be prescribed, and if the disease is once thoroughly checked, skin-grafting into the conjunctival sac may be done, and with good results.

LYMPHANGIECTASIS OF THE CONJUNCTIVA

Lymphangiectasis of the conjunctiva is a condition resulting from the dilatation of the conjunctival lymphatics, which look like small transparent globules and are filled with a transparent fluid. When this condition exists and traumatism occurs these dilated lymph channels may become filled with blood, and finally become a part of the conjunctival vascular system (lymphectasia hemorrhagica (Leber)). The condition usually disappears.

ERYTHEMA MULTIFORME OF THE CONJUNCTIVA

Erythema multiforme occasionally makes its appearance upon the conjunctiva as upon other mucous membranes. The lesions include congestion, papules, vesicles, and a false membrane. These manifestations are characterized by their peculiar violaceous color and are accompanied by injection of the margins of the lids, agglutination of the cilia, a mucoid discharge, and more or less palpebral edema. The condition lasts from four to ten days.

The treatment consists in the administration of a brisk purgative, followed by salol or similar intestinal antiseptic. Locally, mild antiseptic eye lotions should be employed.

XEROSIS OF THE CONJUNCTIVA

SYNONYM: *Xerophthalmos.*

In this disease the conjunctiva is dry, lusterless, and shrunken. When greatly contracted the conjunctiva ceases to aid in the lubrication of the eyeball, and in place of the normal secretion there is a scanty, mucopurulent secretion. In the later stages spots

appear on the conjunctiva tarsi, which are incapable of being moistened by the secretion, and the patient is tormented with a sense of dryness. The condition may spread and involve the entire conjunctiva and cornea. It is probably due to a fatty degeneration of the conjunctiva.

From these spots a bacillus, known as the bacillus of xerosis, may be obtained in great numbers. The disease may be a sequel to trachoma, diphtheritic conjunctivitis, or pemphigus. The cornea very frequently participates in the process, becomes dry and opaque, and sight is eventually lost.

Treatment.—Treatment is of no avail. The eyes should be rested, and protected if necessary by dark glasses. The excessive dryness of the conjunctiva should be combated by suitable instillations, such as glycerin and water. A soothing lotion, such as the boric-acid-and-camphor preparation already described, should be used.

A case came under the author's observation some years ago in which the only relief obtained was by instilling a drop of castor oil into each eye every three to five hours. This treatment has been kept up for ten years. The oil clears up the parchmentlike condition of the cornea sufficiently to enable the patient to find his way around the city.

At night, before retiring, unguentum boroglycerid should be applied to the margins of the lids.

Tarsorrhaphy (suturing together of the margins of the lids at the canthus) has been mentioned by Tiffany as possessing some value in cases in which the cornea begins to ulcerate and necrosis is threatened.

LEPROSY OF THE CONJUNCTIVA

On account of the anesthesia of the lids in leprosy, the conjunctiva is frequently inflamed as the result of exposure to external influences. Nodular leprosy may affect the conjunctiva. Involvement of the iris, cornea, and sclera may occur.

SYPHILIS OF THE CONJUNCTIVA

Syphilis of the conjunctiva, such as chancre, moist papules, and gummata, should always be carefully differentiated from these growths, as their occurrence in this situation is not rare.

AMYLOID DISEASE OF THE CONJUNCTIVA

A rare affection of the conjunctiva, first described by v. Oettingen, characterized by amyloid infiltration of that structure. It is most frequent in young adults, and is often first noticed by the drooping of one or both lids. Redness, hemorrhages, and protrusion may become marked, and often render the eye useless. The condition is not unlike trachoma in appearance, but differs from that disease in that it is yellow, waxy, and transparent. The cause is unknown.

Hyaloid degeneration of the conjunctiva has been observed, but is usually considered a forerunner of amyloid changes (Raehlmann and Kubli). This view is not supported by Vossius. The treatment consists of excision.

LUPUS VULGARIS

Lupus vulgaris or lupus erythematosus may involve the conjunctiva by extension from the face. They present no characteristic symptoms in this situation, but are usually reddish, rough patches, superimposed upon an ulcerated base. The treatment should be directed toward the original area of disease. The prognosis is favorable in all cases.

TUMORS OF THE CONJUNCTIVA

BENIGN TUMORS

Tumors of the conjunctiva may be both benign or malignant. According to J. Herbert Parsons there is a tendency for all the tumors of the conjunctiva to assume the polypoid form. Among the benign tumors found on the conjunctiva are *fibroma, lipoma, dermoids, osteoma, adenoma, granuloma, angioma,* and *papilloma.*

Dermoid Tumor.—This tumor is composed of elements that enter into the formation of the external skin. It is usually flat, solid, and sometimes covered with small hairs. Its color varies from a white to a yellowish red. This tumor is liable to produce considerable irritation and disfigurement. The cornea is, as a rule, involved.

Lipomatous dermoids are usually found between the insertions of the superior and external rectus muscles, associated

with thickening of the conjunctiva. Dermoid tumors are congenital.

Nevi are common on the conjunctiva, and are like those found on the skin, being usually the seat of pigmentation. Cysts are frequently found in these tumors, and according to Wintersteiner they may contain coagula or hyaline concretions.

FIG. 72.—LIPOMA OF CONJUNCTIVA.

Angioma may be capillary or cavernous, and is usually found in children. While it may occur on the bulbar or palpebral conjunctiva, it is usually found on the plica semilunaris. In most cases it is congenital.

Fibroma.—This tumor usually is situated in the upper *cul-de-sac*, although it may also occupy the plica semilunaris. It is frequently very vascular.

FIG. 73.—DERMOID CYST OF THE CONJUNCTIVA.

Granulation tissue tumors may be confounded with polypi, but differ from the latter in that they are not covered by conjunctiva, but frequently break through that structure, as in the case of chalazia or operation wounds. They may be pedunculated or sessile.

Polypi occur occasionally in the fornix, plica semilunaris, or lacrymal caruncle; they bleed easily, and are pale red in color. They may become ulcerated.

Lipoma, or fatty tumor, is a congenital growth of the conjunctiva, having a rough, lumpy surface and a yellow color. It is most often found in the upper and outer quadrant, and lies beneath the conjunctiva.

These tumors should be excised, and the edges of the wound brought in apposition with fine sutures.

Cysts may form in the conjunctiva as the result of traumatism, but are usually congenital. They may arise from dilated lymph vessels or from the sac of a cysticercus cellulosæ. Dermoid cysts are occasionally encountered, and are always congenital. They nearly always remain quiescent, and are distinguished by their characteristic contents common to all dermoids. They can be removed either by incision or curettement.

MALIGNANT TUMORS

Epithelioma is not an infrequent growth of the conjunctiva, and usually begins at the sclerocorneal margin, showing its usual selective affinity for locations where there is a junction of two epithelial tissues. Its growth is slow, and as it advances it often becomes papillomatous or warty in character. Its further progress is marked by destruction of tissue and subsequent malignant course. It may overlap the cornea.

Sarcoma may begin at the limbus or on the inner surface of the upper lid. P. N. K. Schwenk (*Ophthalmoscope*, February 6, 1909) reports a sarcoma of the bulbar conjunctiva. It becomes pedunculated in a short time and extremely vascular. It bleeds upon slight irritation, and may be pigmented. A sarcoma in this location generally grows in height, and may overlap the cornea without involving it. According to Strouse (Knapp's *Archives of Ophthalmology*, No. 26, Vol. I, 1897), an epibulbar sarcoma never penetrates the globe and rarely gives rise to metastasis.

Treatment.—The treatment of these growths consists usually in the removal of all diseased tissues by free excision. This may vary from a simple excision to an enucleation, or even exenteration of the orbit, depending, of course, upon the conditions present. The application of the X-ray is often productive of great benefit without the deformity so common in excision.

INJURIES OF THE CONJUNCTIVA

Foreign Bodies.—The conjunctiva is extremely sensitive, and when a foreign body finds lodgment on it, hyperemia, catarrhal conjunctivitis, and engorgement of the papillæ in the location of the foreign substance result. It is at times difficult to locate a foreign body, especially when it is lost in the superior *cul-de-sac*, or if it is blown into the eye with considerable force and is buried in the tissue. The foreign substance frequently enters the conjunctiva at one spot and then appears at another, especially when the substance is a particle of glass, granite, or steel. Often the pain is very acute, increasing with each movement of the eyelid.

The larger number of foreign bodies, such as coal dust, are loosely attached to the ocular conjunctiva and are easily removed. A drop of cocain (5-per-cent solution) should be instilled if the substance is deeply imbedded. It is necessary, at times, to use focal illumination to aid in the location of a very minute body.

When a small piece of glass is buried in the conjunctiva and only the sharp edge is protruding, and it is impossible to see it with the naked eye, then it is best to locate it with a spud by delicately touching the glass particle—the patient will assist by informing the operator when the foreign body is touched. A small fold of the conjunctiva, in which it is imbedded, is grasped with delicate forceps and is excised with scissors. The tissue that is removed must be examined under a magnifying lens or microscope to make sure that the glass or steel has been brought away. The author has had three cases recently of this character, and in each this method of locating the glass and removing it has been carried out successfully.

The after-treatment consists in local applications on cold compresses of the following formula:

℞ Hydrargyri chloridi corrosivi.	gr. $\frac{1}{75}$;	0.0009
Sodii chloridi	gr. xv;	1.0000
Acidi borici	gr. xx;	1.2000
Aquæ camphoræ, Aquæ destillatæ, }	āā fl ℥jss;	45.0000

Misce. Sig.: Apply on cold compresses.

Burns of the Conjunctiva.—Acids, alkalies, etc., cause whitish patches that are very painful, and if extensive are very serious. The cornea may become implicated, and more frequently the eyelid becomes attached to the eyeball, producing a condition known as *symblepharon*, or *ankyloblepharon*, in which the margins of the lids become attached to each other. Entropion and ectropion may also result.

Treatment.—This must be *prompt*. In acid burns bicarbonate of potash or of sodium is recommended. In burns from alkaline substances, such as lime or whitewash, caustic potash, etc., milk, oil, unsalted butter, or vaselin should be applied as soon as possible. The lotion prescribed under Hordeolum is soothing when applied with absorbent cotton dabs, but is contraindicated if the cornea is involved on account of the lead water which it contains. This may be made cold by placing the cotton in an iced bowl, as described in the treatment of purulent conjunctivitis. Adhesions between the eyelids must be prevented. This may be accomplished by inserting a conformer and allowing it to remain between the eyelids for ten days or two weeks. Egg film has been advised by Coover and Black. It should be renewed daily. Skin-grafting with a graft taken from a mucous membrane, such as the inside of the lip, may be necessary, but should be postponed until reaction has subsided. If the cornea is affected, atropin should be employed. The prognosis is always serious, and an opinion should not be given as to the outcome of the injury until after the third day.

Wounds of the conjunctiva arising from burns, scalds, injury, etc., should always be treated promptly to prevent cicatricial deformities. Incised or lacerated wounds should be united by means of sutures, and granulating surfaces in apposition should be kept apart. Symblepharon and ankyloblepharon are the most common deformities, and are described at length under diseases of the eyelids.

The prognosis is usually favorable.

Emphysema of the conjunctiva may result from trauma to the lids, and is characterized by a tense, elastic tumor, which crepitates on palpation. The treatment consists of a compress bandage.

SUBCONJUNCTIVAL EFFUSIONS

Subconjunctival Ecchymosis.—Effusion of blood beneath the conjunctiva is characterized by a patch or deep red ring surrounding the cornea, and gives to the eye an alarming appearance. It is produced by any operation involving the ocular conjunctiva—by blows, lifting heavy weights, vomiting, whooping-cough, fractures of the orbit or base of skull, and riding through the air at a very rapid rate. Again it is found in certain degenerated conditions of the blood-vessels, such as Bright's disease, scurvy, cholera, etc. They are only important from their symptomatic signification. Their absorption is slow, sometimes occupying two or three weeks. The lead-water lotion, already described, applied three times daily hastens absorption. (See Hordeolum.)

Serous Effusions.—When this appears the conjunctiva is swollen and extends over the cornea, causing it to appear as if the cornea were buried deep in the conjunctiva (*chemosis*). It may even extend between the margins of the lids. This edema is always a symptom of an inflammatory process somewhere about the eye or eyelid; it is found associated with such inflammatory diseases as erysipelas, abscess of the lacrymal sac, or abscess of the orbit, and is a common symptom in purulent conjunctivitis. It is not an uncommon symptom of cardiac or renal diseases. The condition known as angioneurotic edema at times affects the conjunctiva. Cases have been described by Black and Holmes Spicer.

The **treatment** consists of puncturing the conjunctiva and instilling 5 to 10 drops of adrenalin (1–3,000) three times daily, and also applying a bandage.

A somewhat similar condition is present after the subconjunctival injection of salt solution as recommended in diseases of the vitreous, corneal opacities. The large bleb formed usually subsides in about one hour, due to absorption of the saline solution.

PIGMENTATION OF THE CONJUNCTIVA

Argyrosis (*Argyria conjunctivæ*).—Silver nitrate, when employed over a long period, is followed by a discoloration of the

conjunctiva, with the production of various slate-colored and brownish tints. The discoloration is permanent. The silver discolors the elastic fibers, but not the epithelium. No procedure to remedy the condition has yet been found.

De Schweinitz reports a case of argyrosis of the conjunctiva and lacrymal sac from prolonged use of 5-per-cent solution of protargol. The author has met with similar experiences, but more often with argyrol.

Siderosis conjunctivæ is a yellowish pigmentation of the conjunctiva due to a long-continued use of the sulphate of iron.

Other discolorations may be due to the deposition of **bile pigment** which accompanies hepatic disorders. It is usually transitory, and while it may occasion itching and burning of the eyes, it induces no serious result.

Blood pigment may stain the conjunctiva as the result of injuries, coughing, straining, etc. (See Subconjunctival Ecchymosis.)

Urates, in gouty individuals, may be deposited in the conjunctiva, rendering it *opaque* in spots. This condition is most frequent on the palpebral conjunctiva, and is accompanied by the sensation of a foreign body.

CHAPTER VII

DISEASES OF THE CORNEA

GENERAL CONSIDERATIONS

ON account of the cornea being a nonvascular structure there is in the milder forms of inflammation no congestion, though in all varieties of keratitis the blood-vessels of the conjunctiva and sclerotic coat become more or less involved. Inflammation of the cornea occurs either as a primary or secondary affection.

FIG. 74. — CROSS-SECTION THROUGH A NORMAL CORNEA. Magnified 100 × 1.

E, anterior epithelium; *B*, Bowman's membrane; *S*, stroma, composed of the corneal lamellæ, *l*, and the corneal corpuscles, *K*; *D*, Descemet's membrane; *e*, posterior epithelium; *n*, nerves extending through Bowman's membrane and the epithelium.

In various kinds of opacities, phlyctenulæ, or abscesses, it becomes the seat of exudation, which may produce only a faint dimness or haziness of the cornea, or may give rise to an opalescent or even salmon-yellow appearance. Any of the 5 layers of the cornea may be involved, but for simplicity's sake, and so that the student may more easily grasp the subject, this structure has been divided, pathologically considered, into 3 principal layers: (1) *Epithelial layer*

and *Bowman's membrane;* (2) *cornea propria, or substance proper of the cornea,* and (3) *Descemet's membrane and endothelial layer.*

In involvement of the first coat, the inflammatory exudation raises the epithelial layer in the form of a phlyctenule, or there may be a slight haziness without any disturbance of the epithelium. Slight congestion of the conjunctiva at one sector of the corneoscleral margin may be present, or there may be a complete circular involvement.

In involvement of the second coat, the product of exudation enters into the interstitial layer (Recklinghausen spaces) of the cornea propria; hence there may be irregular patches of cloudiness, or if exudation is more extensive, a more pronounced opacity may result. The scleral blood-vessels are more or less congested in this form of inflammation.

When the third coat (fourth layer, histologically speaking), Descemet's membrane, is involved, we find haziness of the deepest layers with minute dots scattered about over the endothelial layers, keratitis punctata (*see "serous cyclitis"*), or more or less turbidity of the aqueous of the anterior chamber. Here, also, the scleral blood-vessels (pericorneal) are more or less congested.

The varieties of these morbid conditions will be more fully described under the different diseases in which they are classified, the term *keratitis* being employed as a general term for inflammations of the cornea. The classification has, according to Fuchs and others, been divided under suppurative and nonsuppurative types.

KERATITIS

PHLYCTENULAR KERATITIS

SYNONYMS: *Eczematous keratitis; Scrofulous keratitis; Strumous keratitis.*

Definition.—This is a superficial inflammatory process of the cornea, characterized by the presence of phlyctenules (blisters), and accompanied by slight redness of the conjunctiva and intolerance of light. It is generally situated near the corneoscleral margin, and may involve both conjunctiva and cornea (phlyctenular kerato-conjunctivitis), and occurs most frequently in children from two to fifteen years of age.

Etiology.—It occurs most often in individuals of a strumous diathesis, but inherited syphilis may be a factor in its production; it may also be due to want of nourishing food, exposure, or lack of cleanliness. Rare cases have been attributed to malaria. The disease frequently coexists with phlyctenular conjunctivitis. It may follow the infectious fevers, and is common in children with adenoid vegetations in the nasopharynx and with general lymphatic enlargement. By some observers microörganisms are held to be the cause of the corneal condition by local infection.

Pathology.—The phlyctenules are small elevations of the corneal epithelium, generally situated near the corneoscleral margin, though occasionally scattered over the corneal epithelium, inclosing a serous fluid which contains broken-down cells and bacteria, but rarely pus corpuscles. This fluid accumulates until the phlyctenule ruptures, allowing it to escape and leave behind a minute rounded ulcer. The ulcer usually heals rapidly under proper treatment, a small nebula and some irregularity of the corneal surface remaining. (See Phlyctenular Conjunctivitis.)

Symptoms.—There is superficial circumcorneal injection, blepharospasm, and excessive lacrymation, often accompanied by epiphora and intense photophobia. The patient complains of a sense of heat or a gritty feeling in the eye. The diagnosis is not difficult.

Treatment.—Internally, the administration of such tonics as Fowler's solution of the arsenite of potassium, combined with the sirup of the iodid of iron, hypophosphites, cod-liver oil, protonuclein, or the elixir of iron, quinin, and strychnin, is indicated in all cases.

The following formula is much used in children from five to fifteen years of age:

℞ Liquor potassii arsenitis .... ʒij; 8
Syrupi ferri iodidi .... ʒiv; 15
Syrupi limonis ....q. s. ad ℥iij; 90
Misce. Sig.: Teaspoonful three times daily.

Locally, insufflations of calomel (if no form of iodin is being taken), finely pulverized, or the application of the following salve will be of great benefit:

℞ Hydrargyri oxidi flavi .... gr. $\frac{1}{8}$; 0.008
Atropinæ sulphatis .... gr. $\frac{1}{4}$; 0.016
Petrolati .... ʒj; 4.000
Olei rosæ ....q. s.

Misce, ft. ung. Sig.: Apply a very small quantity to the eye at night.

Dark glasses should be worn on account of the intense photophobia, in preference to the bandage so frequently employed. The occurrence of true corneal ulceration requires more vigorous local treatment. (See Ulcers of the Cornea.)

Sometimes the disease becomes intractable and does not respond to ordinary treatment. The blepharospasm is often so intense that it is necessary to give the child an anesthetic to stretch the eyelids with lid retractors in order to break the spasm of the orbicular muscle. The ordinary boric-acid lotion should be used frequently during the day.

℞ Acidi borici, }
Sodii chloridi, } ....āā gr. xx
Aquæ menthæ piperitæ .... ʒiij
Aquæ camphoræ, }
Aquæ destillatæ, } ....āā ℥ij

Misce. Sig.: Eye lotion.

Such hygienic measures as fresh air, proper food and clothing, as well as salt baths twice or three times weekly, should be prescribed in addition to medication. The author has frequently found the most beneficial results follow salt baths, general massage, and sponging the body with alcohol.

Prognosis.—In the majority of cases the prognosis is good, provided proper treatment has been promptly instituted. The healing process is slow in the more severe cases, and after repeated attacks more or less cloudiness and scarring of the cornea is always left behind. Relapses are quite frequent, and after several attacks the eye cannot be restored to its normal condition. As a result of the extensive vascularity the cornea remains permanently clouded. In consequence of this vascularity ulcers sometimes form that may lead ultimately to perforation of the corneal tissue.

INTERSTITIAL KERATITIS

SYNONYMS: *Parenchymatous keratitis; Syphilitic keratitis; Diffuse interstitial keratitis; Strumous keratitis.*

Definition.—Parenchymatous or interstitial keratitis, as the term indicates, is a diffuse chronic inflammation of the entire corneal tissue, of constitutional origin, involving the cornea proper and elastic laminæ. It is characterized conspicuously by the absence of any tendency toward the loss of corneal tissue, suppuration or vascularization being very rare in this form of keratitis. There is, on the other hand, deposition of some exudative substance within the cornea that causes an opalescent opacity.

FIG. 75.—INTERSTITIAL KERATITIS.

Etiology.—It is acccepted that inherited syphilis is responsible for the majority of cases. Jonathan Hutchinson (London) estimates 50 per cent of the cases to be due to it. He was the first to call attention to the notched and "pegged-shaped" teeth seen so frequently, and to show their relation to the constitutional disturbance causing this corneal disease. The affection is more frequent in girls than boys, and appears usually during second dentition. Even in adults, congenital syphilis may be considered the most common cause. A lymphatic, scrofulous, gouty, or rheumatic diathesis, as well as climatic vicissitudes, and the acute infectious fevers, particularly malaria, contribute also to the etiology.

Symptoms.—The initial symptoms of this disease are more or less ciliary injection, cloudiness or dullness of the cornea, some lacrymation, and interference of vision. The "steaminess" or "ground-glass" opacity usually commences at the center of the cornea, gradually spreading over the entire corneal surface. Occasionally it may begin at the periphery and gradually extend toward the center. In the more severe cases it reduces vision to little more than light perception.

Examination by means of a magnifying glass reveals the fact that the substance producing this opacity is situated in the deep layers of the cornea, together with an irregularity in its surface due to the pathological processes in that structure. Vascularization of the cornea by extension of the anterior ciliary vessels is frequent, producing the discoloration of the cornea known as the "salmon patch." Subsidence of the inflammation at this

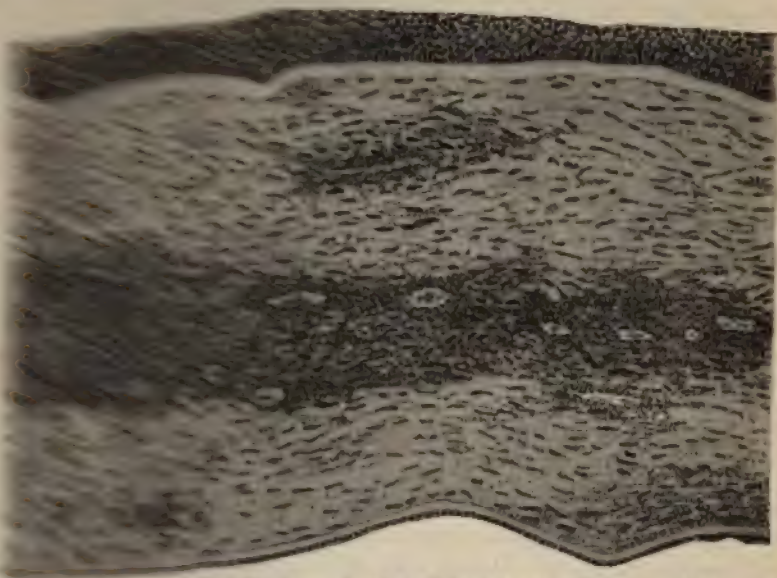

Fig. [illegible].—Interstitial Keratitis, Cross-section of Cornea. (Magnus.)

stage requires a period varying from eight months to one and a half years.

Iritis and the formation of posterior synechiæ are not uncommon in less benign cases. There may be an accompanying retinitis, and the whole uveal tract may sometimes become involved. Both eyes are generally implicated, but seldom, if ever, simultaneously, the process in one eye being usually more extensive than in its fellow. Usually the disease appears in the second eye just as the inflammation is about to subside in the first eye. If the cornea is decidedly swollen, a deposition of gummatous material should be suspected; while this endangers the transparency of the cornea, it does not, however, result in suppuration.

The subjective symptoms include photophobia, lacrymation,

larity of the intestinal movements, it is often necessary to mild, unirritating purgatives.

During the administration of mercurial inunctions g may develop; it then becomes necessary to temporarily

FIG. 78.—VARIOUS TYPES OF KERATITIS.

1, Advancing stage of interstitial keratitis; 2, subsiding stage of interstitial keratiti stage of interstitial keratitis; 4, vascular diffused interstitial keratitis; 5 ar or vascular keratitis; 7, keratitis punctata (Descemetitis); 8, lead deposit in

the administration of all mercurial preparations. Instead cury, iron in medium doses should be substituted. The of the mouth may be greatly relieved by freely and fr cleansing with tincture of myrrh or chlorate of potas

of the yellow oxid of mercury, $\frac{1}{8}$ grain (0.008); daturine sulphate, $\frac{1}{4}$ grain (0.015); vaselin, 1 dram (4.0).

For the absorption of the corneal opacities after acute symptoms have subsided, and sometimes during the acute stage, I have had most gratifying results from the subconjunctival injections of salt solutions in strengths varying from 0.6 to 10 per cent. The formulæ employed are as follows:

℞ Sodii chloridi	gr. v;	0.3
Aquæ destillatæ	fl ℥j;	32.0

Misce. Sig.: Inject 10 to 20 cm. beneath the conjunctiva every second day.

℞ Sodii saccharat (sodium benzoyl sulphonic)	gr. xv;	1
Aquæ destillatæ	℥j;	32

Misce. Sig.: Inject 10 to 20 c.c. beneath the conjunctiva every third day.

The author's experience has led him to adopt the above formulas. This sodium salt has given better results in ulcers of the cornea, interstitial keratitis, iritis, and iridocyclitis, than the normal salt solution, and in the same strengths it is less painful at the time of the injection and subsequently. It must be understood that this line of treatment is applied in conjunction with other local treatments described above.

The distention of the conjunctiva usually disappears in three hours, and no untoward symptoms follow. Immediately after the subconjunctival injection—for this purpose a Lüer glass syringe is used—an antiphlogistic lotion is applied to the eye to reduce the swelling:

℞ Liquoris plumbi subacetatis diluti...	ʒij;	8
Tincturæ opii, Tincturæ belladonnæ, } ....āā	ʒjss;	6
Tincturæ arnicæ	℥j;	30
Aquæ camphoræ, Aquæ destillatæ, } ......āā q. s. ad	℥iv;	120

Misce. Sig.: For local application to the closed eyelids.

The instillation of 1 drop of a 5-per-cent solution of dionin, once daily over an extended period, is of value in bringing about absorption of recent corneal opacities. This treatment is extolled by European authorities for old opacities, but has not been of much service in the author's experience. The drug at first induces promptly an edema of the conjunctiva which lasts about a half hour. A tolerance is soon established for the drug. It should then be withheld for a few days before being again used. Equal parts of powdered dionin and atropin inserted in the cocainized eye on the end of a probe, is often very valuable. (See Serpiginous Ulcer.) The intense blepharospasm met with in this disease is broken by forcibly stretching the lids with lid elevators.

Prognosis.—The prognosis depends largely upon the severity of the disease and the continuation of appropriate treatment. The younger the individual, the more favorable the prognosis. The opacity of the cornea gradually disappears under appropriate treatment after a period varying from a few weeks to several months. This clearing process usually begins at the margin and gradually extends toward the center, the central clouded area being the last to disappear. In many instances, however, even after the deposited material has been absorbed, minute channels remain in the corneal tissue throughout the remaining period of life, producing some imperfection in vision. Relapses of the disease are not uncommon and vision is lessened after each distinct attack. Notwithstanding such conditions, the author has seen the cornea in almost hopeless cases clear up and the patient obtain useful vision.

In presenting a prognosis, it is a good rule at the onset of the disease to predict that the sight will become impaired, and that it may perhaps remain so; it is permissible to say that improvement will occur only after the disease has reached the fastigium.

Among the sequelæ of interstitial keratitis may be mentioned hazy cornea, iritis, iridocyclitis, posterior synechia, and anterior synechia.

VASCULAR KERATITIS

(*Pannus.*)

A superficial vascular keratitis, the result of some irritating influence such as trachoma, trichiasis, entropion, or repeated attacks of phlyctenular keratitis. It is nature's effort to protect

Examination by means of a magnifying glass reveals the fact that the substance producing this opacity is situated in the deep layers of the cornea, together with an irregularity in its surface, due to the pathological processes in that structure. Vascularization of the cornea by extension of the anterior ciliary vessels is frequent, producing the discoloration of the cornea known as the "salmon patch." Subsidence of the inflammation at this

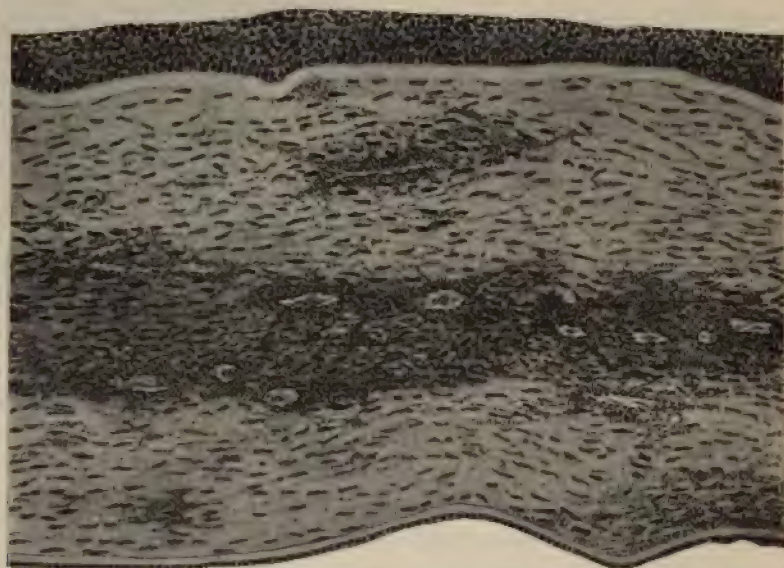

FIG. 76.—INTERSTITIAL KERATITIS, CROSS-SECTION OF CORNEA. (Magnus.)

stage requires a period varying from eight months to one and a half years.

Iritis and the formation of posterior synechiæ are not uncommon in less benign cases. There may be an accompanying retinitis, and the whole uveal tract may sometimes become involved. Both eyes are generally implicated, but seldom, if ever, simultaneously, the process in one eye being usually more extensive than in its fellow. Usually the disease appears in the second eye just as the inflammation is about to subside in the first eye. If the cornea is decidedly swollen, a deposition of gummatous material should be suspected; while this endangers the transparency of the cornea, it does not, however, result in suppuration.

The subjective symptoms include photophobia, lacrymation,

more or less pain, and interference with vision proportionate to the degree of corneal infiltration.

Diagnosis.—The diagnosis of this disease is not difficult, especially in cases of syphilitic origin. In a characteristic case of syphilis we have the following appearance: Square forehead, prominent frontal eminences, Hutchinson lines or scars about the angles of the mouth, and notched and "peg-shaped" teeth.

Fig. 77.—Hutchinson Teeth.

Treatment.—This may be local, constitutional, or both—constitutional being of greater importance. The drug *par excellence* is mercury, and this may be given in almost any form. According to the experience of the author, the best forms, however, are the powder of mercury and chalk for internal administration and the mercurial ointment in inunctions. In fact, it is astonishing how large an amount of mercury a patient who is suffering with this disease is able to bear. The author very frequently has rubbed into children, ten years of age, as much as 10 to 12 ounces before ptyalism makes its appearance, 4 drams being the quantity vigorously applied to the skin daily. The great secret of success is the constant rubbing for a period ranging from ten to fifteen minutes. Different parts of the body should be selected for each inunction to avoid undue cutaneous irritation. The persons to whom the rubbing is intrusted should wear rubber gloves to prevent mercurialization of themselves. The general nutritive processes should also receive attention; hence tonics are indicated, such as Fowler's solution in combination with the sirup of the iodid of iron. Care should be exercised that the patient refrain from the performance of any mental or physical work, although mild outdoor exercise, as walking, driving, etc., should be advised. Nutritious foods are indicated, selecting those that contain an excess of carbohydrates; but tea, coffee, beer, etc., should be eliminated from the diet. The movement of the bowels should be free at all times, and in order to maintain regu-

larity of the intestinal movements, it is often necessary to resort to mild, unirritating purgatives.

During the administration of mercurial inunctions *gingivitis* may develop; it then becomes necessary to temporarily suspend

Fig. 78.—Various Types of Keratitis.

1, Advancing stage of interstitial keratitis; 2, subsiding stage of interstitial keratitis; 3, terminal stage of interstitial keratitis; 4, vascular diffused interstitial keratitis; 5 and 6, pannus or vascular keratitis, 7, keratitis punctata (Descemetitis); 8, lead deposit in the cornea.

the administration of all mercurial preparations. Instead of mercury, iron in medium doses should be substituted. The soreness of the mouth may be greatly relieved by freely and frequently cleansing with tincture of myrrh or chlorate of potassium in

water, or by the internal administration of tincture of belladonna, 5 to 10 drops three times daily. After the pharyngeal inflammation has subsided, mercury may again be administered. In milder cases the vin ol. morrhuæ comp. (Hostelley's),[1] which contains cod-liver oil and mercury, will bring about a cure. In the retrogressive stage, arsenic in the form of Fowler's solution, combined with the sirup of iodid of iron, is a valuable adjunct in the treatment. The following prescription illustrates the combination:

℞ Liquoris potassii arsenitis . fl ʒij (8.0)–ʒiv (16.0)
Syrupi ferri iodidi . . . . . . fl ℥j (32.0)

Misce. ft. sol. Sig.: From 10 to 20 drops daily, in water, according to age.

Attention to the personal hygiene of the patient is of the greatest importance. Fresh air, frequent bathing, outdoor exercises, should never be neglected. According to Dr. McCluney Radcliffe, *thyroid extract* is of great value in the various forms of corneal inflammation. He advises giving a small dose at first, 1 or 2 grains three times daily, watching its effects on the system. He attributes its effects to the influence on the lymphatic system and its power to increase metabolism and nutrition. Intramuscular injections of atoxyl have been highly recommended by Sidney Stephenson.

The local treatment consists in a regular instillation of the atropin solution (1 grain to 3 drams) once daily; the constant mydriasis aids in preventing iritis; also allays the slight irritability of the eye, and reduces the pericorneal redness. If there is excessive hyperemia, decided benefit is derived from the application of leeches to the temple, immediately behind the external angular process.

Relief for the photophobia may be obtained by wearing plane dark glasses constantly.

After the disease has reached its fastigium, the absorption of the exudate gives rise to the clearing of the cornea. This may be greatly hastened by the application of an ointment consisting

[1] Each teaspoonful represents: Cod-liver oil, 21 minims (corresponding to 35 per cent); chlorid of arsenic, $\frac{1}{100}$ grain; bichlorid of mercury, $\frac{1}{120}$ grain; protochlorid of iron, $\frac{1}{4}$ grain; sherry wine, vegetable flavoring.

of the yellow oxid of mercury, ⅛ grain (0.008); daturine sulphate, ¼ grain (0.015); vaselin, 1 dram (4.0).

For the absorption of the corneal opacities after acute symptoms have subsided, and sometimes during the acute stage, I have had most gratifying results from the subconjunctival injections of salt solutions in strengths varying from 0.6 to 10 per cent. The formulæ employed are as follows:

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Misce. Sig.: Inject 10 to 20 cm. beneath the conjunctiva every second day.

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The author's experience has led him to adopt the above formulas. This sodium salt has given better results in ulcers of the cornea, interstitial keratitis, iritis, and iridocyclitis, than the normal salt solution, and in the same strengths it is less painful at the time of the injection and subsequently. It must be understood that this line of treatment is applied in conjunction with other local treatments described above.

The distention of the conjunctiva usually disappears in three hours, and no untoward symptoms follow. Immediately after the subconjunctival injection—for this purpose a Lüer glass syringe is used—an antiphlogistic lotion is applied to the eye to reduce the swelling:

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Tincturæ opii, Tincturæ belladonnæ,	āā ʒjss;	6
Tincturæ arnicæ	℥j;	30
Aquæ camphoræ, Aquæ destillatæ,	āā q. s. ad ℥iv;	120

Misce. Sig.: For local application to the closed eyelids.

The instillation of 1 drop of a 5-per-cent solution of dionin, once daily over an extended period, is of value in bringing about absorption of recent corneal opacities. This treatment is extolled by European authorities for old opacities, but has not been of much service in the author's experience. The drug at first induces promptly an edema of the conjunctiva which lasts about a half hour. A tolerance is soon established for the drug. It should then be withheld for a few days before being again used. Equal parts of powdered dionin and atropin inserted in the cocainized eye on the end of a probe, is often very valuable. (See Serpiginous Ulcer.) The intense blepharospasm met with in this disease is broken by forcibly stretching the lids with lid elevators.

Prognosis.—The prognosis depends largely upon the severity of the disease and the continuation of appropriate treatment. The younger the individual, the more favorable the prognosis. The opacity of the cornea gradually disappears under appropriate treatment after a period varying from a few weeks to several months. This clearing process usually begins at the margin and gradually extends toward the center, the central clouded area being the last to disappear. In many instances, however, even after the deposited material has been absorbed, minute channels remain in the corneal tissue throughout the remaining period of life, producing some imperfection in vision. Relapses of the disease are not uncommon and vision is lessened after each distinct attack. Notwithstanding such conditions, the author has seen the cornea in almost hopeless cases clear up and the patient obtain useful vision.

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Among the sequelæ of interstitial keratitis may be mentioned hazy cornea, iritis, iridocyclitis, posterior synechia, and anterior synechia.

VASCULAR KERATITIS

(*Pannus.*)

A superficial vascular keratitis, the result of some irritating influence such as trachoma, trichiasis, entropion, or repeated attacks of phlyctenular keratitis. It is nature's effort to protect

the cornea from injury by the hard cicatricial tissue found in granular lids. The pannus may exist in any form of granular lids, even when the papillæ are soft and gelatinous.

It is classified under three varieties: *Pannus tenuis*, very slight vascularity; *pannus vascularis*, increased vascularity of the cornea; *pannus crassus*, or *carnosus*, in which the cornea is extremely vascular and assumes a red, fleshy appearance.

Pathology.—The blood-vessels form a fine and tortuous meshwork immediately beneath the epithelial layer, extending from the limbus of the conjunctiva toward the center of the cornea. In long-standing cases the author has seen Bowman's membrane considerably changed by the invasion of new-formed blood-vessels and pathological products. In such cases the cornea always remains slightly cloudy. The condition is believed by some to be a part of the trachomatous disease and not merely the result of irritation. It is accompanied by destruction of the corneal epithelium, and disappears with its regeneration.

Treatment.—When due to trachoma, the grattage operation should be performed at once, and this should be followed immediately by Burow's operation (an incision of the cartilage from the inner to the outer canthus). The author has performed peritomy in all cases where the lids are apparently smooth, and yet the pannus persists. The treatment should always be directed toward the granulations or similar conditions of the lids that may be considered causal. Some of the older authorities advocate the pernicious practice of inoculating the palpebral sac with the discharge of ophthalmia neonatorum or the infusion of the jequirity bean in cases of trachoma. This is mentioned only to be condemned.

Prognosis.—This depends entirely upon the extent to which the deeper layers of the cornea are involved. In most cases the vascularity gradually disappears after the cause has been removed, but in *pannus crassus* of long standing particularly, considerable cloudiness of the cornea is the best that can be expected.

SUPPURATIVE KERATITIS

Under this heading may conveniently be considered ulcers of the cornea, especially serpiginous ulcer, purulent and traumatic

ulcers, neuroparalytic keratitis, lagophthalmic keratitis, and xerotic keratitis.

GENERAL CONSIDERATIONS OF ULCERS OF THE CORNEA

Ulceration of the cornea is always a terminal stage of some inflammatory disease of that structure, resulting in its molecular death and regeneration by scar tissue. In the early stage the cornea is clouded as a result of a dense aggregation of leucocytes, which takes a prominent part in inflammatory reaction. As the condition progresses the exudate is either thrown off, leaving a shallow base, or is retained as an abscess of the cornea, either of which terminations may be followed by perforation depending upon the intensity of the inflammation, the nutrition of the cornea, the character of the treatment, etc. The final stage is characterized by the filling up of the ulceration by connective tissue which may embed the iris or other prolapsed tissue, but regeneration of the cornea never occurs except in the most superficial cases. The new-formed scar tissue being more dense than the corneal tissue, offers great obstruction to perfect vision.

In all corneal ulcerations the pathology is much the same, but owing to the innumerable circumstances that may modify their course, duration, and manifestations, it is customary to describe several distinct clinical varieties. The principal varieties are considered only as regards the differences in the appearances they present, and are discussed under separate headings. Corneal ulcers may arise without obvious cause, but upon careful inquiry and examination they may be traced to injury, impaired nutrition, infection, or extension from adjacent inflammations. The injury that may induce these changes varies greatly in extent and character, and is usually associated with the introduction of microörganisms. Ulceration from impaired nutrition may follow undue exposure, as in trigeminal palsy, lagophthalmos, exophthalmos, facial paralysis, and deformities of the lids; but here also the exciting cause is some form or combination of microörganisms. Xerotic keratitis belongs to this class, and occurs in greatly debilitated children. The ulceration is attended by no active inflammatory symptoms. Infection of a wounded corneal surface by the staphylococcus, streptococcus, pneumococcus, diphtheria

bacillus, tubercle bacillus, aspergillus fumigatus, etc., may induce any form of corneal ulceration, but is more marked in the serpiginous form and in abscess of the cornea. The infectious

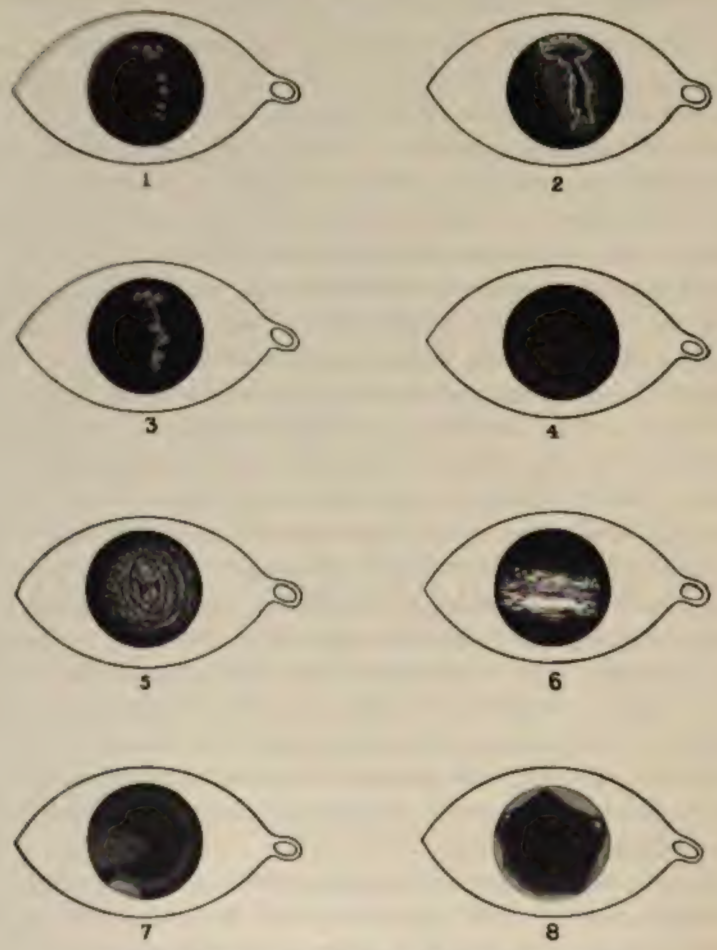


FIG. 79.—VARIOUS TYPES OF CORNEAL ULCERS.

1, 2, and 3, Herpes corneæ febrilis (Horner); 4, Descemetitis; 5, traumatic keratitis; 6, ribbon-shaped keratitis; 7, comet-shaped ulcer; 8, marginal keratitis.

fevers, such as smallpox, scarlet fever, measles, typhoid, typhus, pyemia, etc., may induce ulceration by their local lesions attacking the cornea, by malnutrition, or by the presence of bacteria or their poisons in the blood. As examples of corneal ulcers due to

extension may be mentioned those occurring in phlyctenular disease and purulent inflammation of the conjunctiva and other ocular structures.

Ulcerative inflammations may involve a portion, all of the epithelium, Bowman's membrane, or the cornea propria. The membrane of Descemet does not seem liable to ulceration, but will burst when exposed by loss of corneal tissue.

SIMPLE ULCER

This is a small grayish spot located at the corneoscleral margin, or on the cornea itself, which may result from breaking down of a phlyctenule, or at times may be due to traumatism. It appears as a small phlyctenule (blister) or a "gouged-out" depression in the substance of the epithelium and Bowman's membrane. These ulcers are of various sizes, scarcely ever larger than a millet seed. The "comet-shaped" ulcer or keratitis fascicularis progresses rapidly, eating its way across the cornea, not over 2 or 3 mm. in width, followed in its train by new-formed blood-vessels. In the simple ulcers pus is never present, but pain, photophobia, and lacrymation may or may not occur. There is usually more or less pericorneal injection. The progressive character of the simple ulcer shows itself by the nebulous color of its edges.

The soluble sodium salt of *fluorescin* (fluorescin (ʒss (2.0), sodium bicarbonate ʒiss (3.0), water to make ℥iij (90.) has been used for the diagnosis of corneal lesions and detection of minute foreign bodies embedded in the cornea. While a weak solution of fluorescin will not stain the normal cornea, ulcers or parts deprived of epithelium will become green and remain so for a long time; foreign bodies will appear surrounded by a green ring; loss of substance in the conjunctiva is indicated by a yellow hue. Fluorescin also reveals defects of the endothelium of the cornea and produces a deep coloration of the cornea if the endothelium is absent or diseased. Ophthalmic disks containing $\frac{1}{250}$ (0000.6) grain of fluorescin in combination with sodium, $\frac{1}{20}$ grain (0.003), are made, and it is a very convenient way of applying the drug.

Etiology.—In infants this form of ulcer is due to alterations in nutrition, dentition, or the mild eruptive fevers. In older

children it is usually found in those who have developed strumous tendencies.

Treatment.—Locally, mydriatics are employed to dilate the pupil and to place the eye at rest. An ointment containing the yellow oxid of mercury, ⅛ grain (0.008) to 1 dram (4.0), together with a solution of nitrate of silver, 1 grain (0.06) to 1 ounce (30.0), is of great value. The dusting of levigated calomel into the eye is a useful adjunct to the remedies just mentioned, provided no iodin is being administered internally, all of which are well known and are efficacious. In the more intractable and superficial ulcers the author has found subconjunctival injections of saline infusion of great value, especially those that have resisted the action of mercury.

℞ Sodii saccharati (sodium benzoyl sulphonic)	gr. xv;	1.0
Aquæ destillatæ	fl ℥j;	30.0

Misce. Sig.: For subconjunctival injection.

In the superficial ulcers with an invasion of blood-vessels running over the cornea, scarification at the corneoscleral margin or a partial peritomy is valuable; this should be followed by the use of the following formula:

℞ Daturinæ sulphatis	gr. ½;	0.03
Acidi borici	gr. vj;	0.40
Phenolis	gr. j;	0.06
Aquæ destillatæ	fl ℥j;	30.00

Misce. Sig.: Five drops in the eye four times daily.

Internally, Fowler's solution of the arsenite of potassium and the sirup of the iodid of iron, in small doses, should be administered three times daily. Good nourishing food, fresh air, and hot salt baths at night should not be forgotten. Intranasal conditions should be inspected.

CORNEAL SUPPURATION IN GENERAL

Definition.—An inflammatory disease of the cornea, characterized by a suppurative process, resulting in loss of corneal tissue.

Etiology.—This affection may occur at any age, being due primarily to insufficient power of the corneal tissue to resist the action of infective bacteria, such as the staphylococcus pyogenes aureus, Klebs-Löffler bacillus, and the pneumococcus. It may occur as a complication or extension of an inflammatory process in adjacent tissues (purulent conjunctivitis, for example), or as the result of impairment of the general health, as in tuberculosis, rheumatism, and malignant diseases, malnutrition of the corneal tissues, traumatism, and uncleanliness. It is not uncommon as a sequel of lacrymal disease.

There are two varieties of this disease, viz.:

1. Inflammatory.
2. Noninflammatory, or indolent.

Either of these two varieties may be diffuse or circumscribed. The first type presents acute inflammatory symptoms; the second type is characterized by a breaking-down or sloughing of the corneal tissue without pronounced inflammation.

Symptoms.—If the keratitis is of the inflammatory type the patient complains of intense pain, photophobia, and lacrymation. In the noninflammatory variety, there may be a total absence of subjective symptoms.

A suppurative keratitis may develop from an apparently simple ulcer, from the rupture of an abscess of the cornea, or from bruised or infiltrated tissue. The symptoms are very similar to those produced by a simple form of ulcer, although usually they are more rapid in their onset and very much more intense.

In the diffuse variety, the cornea loses its brilliancy and assumes a grayish-white appearance, soon acquiring a yellow tinge, due to the formation of pus. The process of infiltration and suppuration goes on very rapidly, the entire involvement of the cornea taking place in a period ranging from a few hours to several days.

Occasionally the deeper tissues (cornea propria and Descemet's membrane) are involved in the sloughing process, which produces a perforation leading into the anterior chamber.

The immediate danger of purulent inflammation of the cornea is perforation. Suppuration of this tissue is always followed by ulceration or destruction of its substance, with consequent impairment of the tissue's transparency. When perforation takes place,

the fluid in the anterior chamber escapes, bringing the lens and iris in immediate contact with the posterior limiting membrane of the cornea (anterior synechia). Occasionally the fluid within the eyeball presses against the iris and causes it to be pushed into and through the perforation (hernia of the iris). The presence of pus in the cornea is known as *onyx*, and a similar condition in the anterior chamber constitutes *hypopyon*.

The ulcerated surface is now rapidly covered by a plastic exudate, which soon becomes organized, forming one mass of scar tissue, and filling up the fistula. Spontaneous cures of perforating ulcers have been frequently recorded. The fluid in the anterior chamber escapes, causing the anterior surface of the crystalline lens to come in contact with the inner opening of the fistula. A plastic exudate is hurriedly thrown out into the fistulous tract and undergoes organization; this fills the opening produced by the disintegrating process and permits the reaccumulation of aqueous humor in the anterior chamber, already partially reformed. As a result of this, pressure is exerted upon the anterior surface of the lens by the fluid, tearing the adhesions forcing the lens back to its former position, and allowing a complete reestablishment of the anterior chamber. The lens capsule, as a result of these adhesions, may or may not remain slightly opaque.

Treatment.—Atropin, 1 grain (0.06) to 3 drams (12.0), should be instilled into the eye twice daily, both for its sedative effect and also to prevent adhesions of the iris to the cornea. Sometimes atropin produces an irritation; if so, daturin should be used instead, 1 grain (0.06) to 3 drams (12.0). The ulcer itself should be disinfected as thoroughly as possible by bathing the eye frequently with a very mild bichlorid solution (1–10,000) and immediately thereafter irrigating it with a sulphocarbolate of zinc or chlorid of zinc (2 grains (0.12) to distilled water, 1 ounce (30.0)), or 20-per-cent solution protargol. If any foreign bodies, such as dust, steel, etc., are lodged in the floor of the ulcer, they should be carefully removed in order to lessen the irritation.

If the ulcer is of the noninflammatory type, it should be stimulated to active inflammation by means of the cautery. The best treatment for active inflammatory ulcers is to apply trichloracetic acid (15- to 25-per-cent solution) every third or fourth

day. If the ulcer is one that spreads rapidly and will not yield to solutions of nitrate of silver or strong bichlorid of mercury or even trichloracetic acid, it should be gently curetted, and the actual cautery applied to its base to destroy the infected tissue. Such a procedure seems hazardous, but its value can be readily understood when it is remembered that most of the infected tissue is thereby destroyed, and, besides, its stimulating action causes an excess of lymph to flow from the vessels, extending in the direction of the ulcer, thus limiting the infective, disintegrating process to a greater or less extent. The operation, singularly enough, is absolutely free from pain. Enzymol (50 per cent), locally applied to these ulcers, seems to be productive of great benefit.

When perforation threatens, paracentesis should be performed at once. This relaxes the corneal fibers by permitting the escape of the aqueous humor. The operation is performed by inserting a broad needle, or keratome, into the corneal tissue near its lower margin directly into the anterior chamber. Removal of the aqueous humor is facilitated by gently twisting the keratome within the wound, thus enlarging its opening. The Saemisch operation, which consists in dividing the ulcer into halves horizontally, the incision extending through the corneal tissue at both extremities, is sometimes employed and is of great value in selected cases.

The general health of the patient must be carefully looked after, and improved as much as possible.

Both eyes should be tightly bandaged to insure the greatest amount of rest possible.

Prognosis.—As can be readily seen from the history and course of this affection, the ultimate result depends entirely upon whether perforation has or has not taken place. In nonperforative ulcers appropriate treatment is attended by amazing results, but in the other variety irreparable damage is usually produced.

SERPIGINOUS ULCER

SYNONYMS: *Ulcus serpens corneæ* (Saemisch); *Hypopyon-keratitis* (Roser); *Creeping ulcer of the cornea.*

Etiology.—Serpiginous ulcer of the cornea, if typical, is almost always caused by the *pneumococcus* (Fränkel-Weichselbaum), as discovered by Uhthoff and Axenfeld. Those ulcers

which do not assume the typical serpiginous character (atypical hypopyon ulcer) are generally caused by staphylococci, streptococci, and various other organisms.

Symptoms.—This ulceration is a very obstinate and troublesome form of the infectious variety. It has a curved and wavy margin and yellow base, showing a tendency to spread over the surface of the cornea unattended by vessels of repair, leaving in its path infiltrations of pus or broken-down corneal tissue. Hypopyon is almost always present, and iritis is likely to occur as a complication. Indeed, the hypopyon may develop to such an extent as to cause occlusion of the pupil. The *early* occurrence of hypopyon and iritis are most important points in the diagnosis of this affection. The subjective symptoms consist of severe supra-orbital pain, tenderness of the eyeball, and reduction in vision which may progress until only light perception remains. Perforation is sure to take place in this form of ulcer if allowed to progress.

Prognosis.—The prognosis is always grave on account of the impending destruction of the cornea. Cases left untreated are very apt to result in blindness.

Treatment.—The virulence and rapid spread of the infection demand the most prompt and energetic treatment, which may be medicinal or operative, according to the exigencies of the case. The medicinal treatment consists of the instillation of atropin (sterile solution), dusting the ulcer with iodoform, and the application of a dry sterile bandage. Subconjunctival injections have been recommended. However, where the ulcer has shown any tendency to rapid progression, more energetic measures are indicated. If, therefore, it becomes evident that the ulcer is not only spreading, but that the deeper layers of the cornea are involved or threatened, then cauterization must be performed,

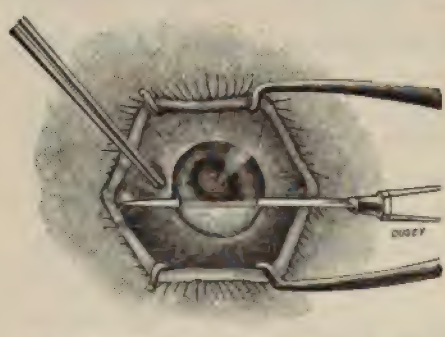


FIG. 80.—SAEMISCH'S SECTION IN HYPOPYON-KERATITIS, SHOWING KNIFE *IN SITU*, JUST BEFORE COMPLETION OF CORNEAL SECTION.

either with chemicals or with the actual cautery (either a galvano cautery or a knitting needle heated to the proper degree). Among the topical applications the author has found a 10- to 20-per-cent solution of trichloracetic acid of great value, as well as an 8-per-cent solution of iodin vasogen. (See Treatment of Purulent Ulcer.)

Recently the author has had very gratifying results in a number of cases from the local application of equal parts of powdered *atropin* and *dionin.* The eye having been cocainized, a canaliculus clamp is applied. After the drugs have remained on the ulcer and become distributed over the conjunctiva, the eyeball is irrigated with a boric-acid solution, and as an additional precaution against the fluid entering the nose, the head of the patient is so turned that the irrigating fluid will run out of the eye in the direction of the outer canthus.

If the ulcer does not yield to the above treatment, then a Saemisch's operation must be performed.

PURULENT ULCER

Purulent ulcer frequently follows an injury, and is very common among farmers and those following the mechanical trades, such as stonecutters, masons, etc. The author has seen many cases in which farmers, while thrashing, were struck in the eye by flying grains of wheat, causing the cornea to be bruised, and followed by the loss of the eye. The same condition is found when the eye is struck by a small piece of stone. A sharp bit of steel in penetrating the cornea rarely produces ulceration; it is only when the fragment has been removed or an attempt has been made to remove it by a mechanic in the shop with a blunt point of a penknife or toothpick that infection follows.

Treatment.—The treatment of the different varieties of infected or purulent ulcers is essentially the same. A mydriatic should be applied once or twice daily; this dilates the iris and puts the ciliary body at rest, as well as depletes the blood-vessels. The eye should be thoroughly douched with an antiseptic wash, in which the following drugs are used, either singly or in combination: boric acid, zinc chlorid, sulphocarbolate of zinc, and sulphate of hydrastin.

The direct application of nitrate of silver, in solid stick or strong solution (10 to 20 grains to the fluid ounce), is also advised; even the actual cautery may have to be employed. Dr. Alexander Duane advocates iodin-vasogen instead of tincture iodin. Pure carbolic acid may also be applied directly to the ulcer.

The trichloracetic-acid application (10- to 25-per-cent solution), once daily, as advised by Dr. D. H. Coover, is most valuable. It is necessary to anesthetize the eye before using this drug. Hot fomentations of poppy heads are used to relieve the intense pain; they should be applied frequently during the day. The eye should be bandaged to prevent the eyelids from irritating the ulcer.

Sequelæ.—When there has been more or less destruction of the corneal tissue, leucoma of a more or less pronounced type may be expected. The location of these opacities in the cornea determines the loss, or at least interference, of vision. A central leucoma may render the eye blind for practical purposes, vision being obtained only when mydriasis is produced. If iritic complications are present, loss of vision may be produced by the adhesions formed or by the glaucoma that may develop. If the cornea alone has been attacked, anterior staphyloma may follow.

Hypopyon.—This condition is characterized by an accumulation of pus at the bottom of the anterior chamber. It is usually dependent upon an abscess or suppurating ulcer of the cornea, or upon some process or suppuration involving the iris, ciliary body, retina, or choroid, etc. The quantity of pus in the chamber varies; sometimes it is hardly perceptible, while at other times it may nearly fill the chamber. It presents a yellowish hue when viewed through the clear cornea.

Onyx.—The accumulation of pus between the corneal laminæ is termed onyx. It can generally be distinguished from hypopyon by the irregular limits of the pus deposit. If the pus in hypopyon is fluid enough, movements of the head will cause it to move also, making a fluid-level, and in such a case the diagnosis is at once established. Focal illumination will generally serve to distinguish these conditions, although they may sometimes coexist.

Treatment.—The cause should be attacked as early as possible, its removal being followed by the rapid disappearance of the pus. It is sometimes necessary to perform an incision in the lower third of the cornea (Saemisch) with a von Graefe knife, to the extent of one half of its diameter, to evacuate the pus (see Fig. 80), which should never be evacuated if the hypopyon is due to iridocyclitis, or suppurating chorio-retinitis, as long as there is an opportunity of saving the eyeball from panophthalmitis by intense medication. The onyx will disappear after the local application of hot fomentations and yellow oxid-of-mercury ointment and the internal administration of gray powders, 2 grains (0.12) three or four times daily. Leeches may be applied to the temple to relieve the pain.

Chandler of Boston and Risley of Philadelphia report favorably on the use of cassaripe (the inspissated juice of the cassava, a tropical plant) in ointment (10 per cent) in the treatment of corneal ulcers and infective inflammations, such as purulent ophthalmia. Although highly antiseptic, it is devoid of irritating properties and may be freely rubbed into the conjunctival folds two or three times daily. Irrigation by means of boric-acid lotion and the application of a pressure bandage in corneal affections increases its good results materially.

TRAUMATIC ULCERS

Traumatic ulcers should be treated antiseptically as soon as possible after the injury has been received. They become, as a rule, infected by the foreign body, if it is allowed to remain in the wound and neglected; if it is superficial and promptly removed the corneal epithelium soon regenerates. After the foreign body is removed, it is well to irrigate the eye with a solution of boric acid. Atropin drops should be instilled at once, even if the patient is fifty years of age or older, and the eye bandaged with an iced pad.

Frequently a scratch from a finger nail or a bruise of the cornea by a foreign body that does not become lodged in it, produces an ulcer. When these accidents occur, the treatment already described should be immediately instituted. Interference with the vision will depend on the location of the injury; if it is on the

margin of the cornea, the sight will not be noticeably interfered with; the more nearly it approaches the center the greater will be the interference.

If the ulcer is seen several days after the injury and pus has developed or hypopyon made its appearance, the application of iodin-vasogen (10 per cent) or a 20-per-cent solution of trichloracetic acid is most beneficial, and the good effects become manifest after three or four applications. When trichloracetic acid is first applied to the ulcer the spot becomes white, like coagulated albumin, and the pain, for a few minutes, is very severe; therefore cocain should always be applied first. In twenty-four hours, however, the cornea will assume a healthy appearance, the ulcer will have become clearer, and the pus, if any is present, will disappear with greater rapidity than under any other treatment that the author has tried.

A patient recently came under my care with a cornea which had been punctured by a table fork, an infected wound being the result. The case was first seen thirty-six hours after the accident.

The corneal puncture was distinctly outlined by a circle of infiltration; pus was present in the layers of the cornea; there was marked hypopyon; the iris was contracted, and apparently infiltrated, and iritis was developing. The case was a desperate one, and loss of the eye seemed inevitable. A 5-per-cent solution of cocain was first instilled to mitigate the pain of the acid application, and after several minutes had elapsed the puncture was touched with a 25-per-cent solution of the trichloracetic acid. The condition of the cornea after the application was rather startling; the spot and its adjacent vicinity turned as white as the albumin of a boiled egg. Atropin was then instilled, the eye bandaged, and the pad kept saturated with the lead water, opium, and belladonna lotion, leaving out the lead water in this case. At the end of twenty-four hours the cornea was clear, the zone of pus infiltration had materially lessened, and there was a marked decrease of the hypopyon. After 3 applications (25, 15, 10 per cent successively) of the acid the pus had entirely disappeared and the iris cleared up, the eyeball was saved, and useful vision restored.

NEUROPARALYTIC KERATITIS

This affection derives its name from a dullness and slight cloudiness of the cornea, finally leading to anesthesia of that structure. It is frequently a result of paralysis of the ophthalmic division of the trigeminus.

Etiology.—Various causes have been assigned: Operation for removal of the Gasserian ganglion; diseases affecting the nuclei of the trigeminus; injuries to the skull; diseases of the cranial bones or meninges; orbital periostitis; tumors in the region of the pituitary body.

Symptoms.—The disease begins in the deeper corneal structures, a depression soon showing itself similar to that seen in desquamations of the epithelium. In severe cases this depression rapidly increases in size, the cornea becomes more cloudy, hypopyon occurs, the cornea finally breaking down. One of the important symptoms is local anesthesia. This can be ascertained by taking a small pledget of cotton and touching the cornea.

Prognosis.—The prognosis is unfavorable, marked opacity of the cornea usually occurring, and leading to extensive reduction of vision.

Treatment.—This consists in the application of warm compresses and instillation of atropin; a bandage or a Buller's shield should be applied. Stitching together of the lids is frequently recommended, and is used as a preventive measure in operations for excision of the Gasserian ganglion. Hypodermic injections of strychnin in the temple have been recommended (Nieden).

LAGOPHTHALMIC KERATITIS

(*Keratitis e Lagophthalmo*)

This form of keratitis is due to imperfect covering of the cornea by the lid resulting in a drying of the cornea. It is usually found in paralysis of the orbicularis palpebræ muscle. It may also occur in destruction of or cicatricial changes in the eyelids.

Treatment.—In addition to removing the cause complete approximation of the lids must be accomplished by means of a

carefully applied bandage. The eye should be frequently cleansed with a mild boric-acid solution.

XEROTIC KERATITIS

(Xerophthalmic Keratomalacia)

This is a rare disease described by von Graefe, and is a disease peculiar to childhood.

Etiology.—Xerotic keratitis is a disease affecting the ill-nourished and those whose power of resistance has been diminished as the result of other diseases, especially the infectious ones. Microörganisms have been described as the cause, but none as yet have been successfully isolated.

Symptoms.—One of the first symptoms is dryness of the conjunctiva, which is often preceded by lacrymation. Small triangular patches of xerotic conjunctivitis soon appear on both sides of the cornea, followed by involvement of the cornea, which in time may lead to perforation.

Prognosis.—The prognosis is grave, the patients generally succumbing from exhaustion.

Treatment.—The treatment is essentially reconstructive in character, and upon this will depend the course and result of the ocular affection. The hygienic conditions should be of the best, tonics and nourishing food should be given, and the ocular involvement treated symptomatically.

NONSUPPURATIVE TYPES OF KERATITIS

DENDRITIC OR BRANCHING ULCER

SYNONYMS: *Keratitis dendritica; Ulcerans mycotica; Dendritic keratitis; Malarial ulcer.*

This variety of ulcer has been so named on account of its peculiar shape, not unlike the figure seen in the moss agate or shrubs observed in fossils.

It is slow in progress, being rarely found active in inflammatory reaction, but when such is the case it is attended by photophobia, lacrymation, edema of the upper lids, denuded epithelium over the track of the ulcer, etc. It is seen in young people of

low vitality and in older individuals of irregular habits and depleted constitutions.

The cause is still unknown, although it is believed that a microörganism is responsible for its development.

Treatment.—Internally, strong mineral tonics and nourishing food. Locally, a few drops of an eye lotion, containing chlorid of zinc (2 grains (0.12) to the ounce (30.0) of distilled water), 4-per-cent formalin solution, should be instilled three times daily, and 1 or 2 drops of a solution of scopalamine hydrobromate should be used to dilate the pupil. Iodin-vasogen (6 to 10 per cent) or iodoform vasogen (3 per cent) is also efficacious.

The pain in this variety of ulcer is sometimes agonizing, requiring hypodermatic injections of morphin. The author has succeeded in reducing the iritis and cyclitis which often complicate the situation by the administration of rapidly increasing, and massive doses of the salicylates, in the same manner as advised by Harold Gifford, of Omaha, in the treatment of sympathetic ophthalmia (*q. v.*).

MALARIAL TYPE

This form of ulcer occasionally occurs in persons who are or were the sufferers of malaria. The ulcer has no characteristic shape, in some cases being round, in others irregular, and in still others developing into branches much resembling the dendritic ulcer. The symptoms are similar to those given under the heading of suppurative ulcer.

Treatment.—The administration of quinin and arsenic internally will cause it to disappear.

Locally, the following formula is advised:

℞ Hydrastinæ hydrochloridi	gr. ss;	0.03
Aquæ rosæ	fl ℥j;	30.00
Aquæ laurocerasi	fl ℥ij;	60.00
Aquæ destillatæ	q. s. fl ℥ij;	180.00

Misce. Sig.: Bathe eyes freely three times daily.

KERATITIS BULLOSA

(*Keratitis vesiculosa*)

This is an uncommon form of corneal inflammation which occurs as a symptom of iridocyclitis, interstitial keratitis, or

glaucoma, and is characterized by vesicles and blebs on the corneal surface, with its subsequent cloudiness. The opacification most frequent in connection with ocular diseases. The true nature of the affection is unknown.

The **symptoms** include pain, photophobia, lacrymation, pericorneal injection, and the eruption of the vesicles and blebs which tend to rupture, leaving behind abrasions and ulcerations of the cornea. Relapses are frequent and the symptoms are markedly exaggerated with each outbreak of the lesions.

The **treatment** consists in the free administration of tonics and stimulants, particularly quinin, especially if malaria is suspected. Locally, puncture of the blebs should be performed, after which the bases should be treated as ordinary corneal ulcers. The attendant ocular inflammation should receive appropriate treatment according to its character. Operative procedures, such as enucleation and iridectomy, may be necessary.

HERPETIC KERATITIS

SYNONYMS: *Sand-blast keratitis; Keratitis superficialis punctata; Keratitis subepithelialis centralis.*

A rare form of corneal inflammation, which attacks only the epithelial layers of the cornea. The inflammation commences at the top of the cornea and advances slowly downward until the whole of the epithelial surface is involved. It is almost invisible to the naked eye, and can only be seen clearly under a magnifying lens or a corneal microscope. To the naked eye it has the appearance of being studded with minute points, like a sand-blast surface. Under the corneal microscope the epithelial layer of the cornea is dotted with isometric spaces (facets) of denuded epithelium. On account of the exposure of Bowman's membrane, or more probably the nerve endings in the cornea, the disease is associated with more or less pain. Its sand-blast appearance causes it to resemble an herpetic condition, but there is *complete absence* of true vesicle formation, the spots being probably due to enlarged or opaque corneal corpuscles or to the filling of the lymph spaces with opaque material.

There is very little or no pericorneal injection of the conjunctiva in the milder forms; it is only when the whole of the

epithelium seems to be exfoliated that a redness of the ciliary zone is noticed. The impairment of vision is in proportion to the degree of epithelial involvement and its location.

Treatment.—Internally, full doses of quinin sulphate, iron, and strychnin, or Fowler's solution of the arsenite of potassium should be administered. Locally, insufflations of levigated calomel are employed. As an eye salve, the following formula is useful: Hydrarg. ox. flav., grain $\frac{1}{8}$ (0.008); daturin sulph., grain $\frac{1}{4}$ (0.016; ichthyol, grain $\frac{1}{4}$ (0.016); petrolatum, dram 1 (4.0). This line of treatment brings about restoration of the epithelium. In very severe conditions it becomes necessary to apply a 5-per-cent solution of trichloracetic acid once every second day. Hot fomentations (120° F.) of poppy heads should be applied constantly to relieve pain.

Prognosis is favorable; the disease runs its course from one to six weeks without any permanent disturbance of vision.

RIBBON-SHAPED KERATITIS

Ribbon-shaped keratitis (*keratitis trophica; zonular opacity* (Fuchs)) is a trophic degeneration of the anterior layers of the cornea, characterized by thickening and roughening of the corneal surface, with its subsequent cloudiness. The opacification becomes more marked, and seems to be due to the deposition of calcareous plaques. According to Treacher Collins, the peculiar shape and development of the lesion may possibly be due to pressure of the lids. The disease is most frequent in eyes that have undergone retrograde changes as the result of glaucoma, iritis, etc., in one variety, while in the primary form, which is quite rare, it occurs in elderly individuals with otherwise sound eyes. Mild irritative symptoms are present and considerable alteration in vision is produced. Treatment is of no avail.

KERATITIS PUNCTATA

Keratitis punctata is not a true corneal disease, but consists merely in the deposition of opaque material in the form of spots on the posterior elastic lamina or membrane of Descemet. They are usually triangular in arrangement, with the apex toward the pupillary margins. This condition is always secondary to

some disease of the iris, choroid, or vitreous, and is described in connection with these affections. (See Serous Cyclitis.)

HERPES OF THE CORNEA

Herpes corneæ is the term applied to herpes zoster of the ophthalmic nerve attacking the cornea, and should not be confounded with keratitis herpetica or keratitis bullosa.

It is also applied to a herpetic condition of the cornea which occurs in disturbances of the respiratory tract, as in influenza, pneumonia, laryngitis, tracheo-bronchitis, whooping-cough, etc. (*Herpes corneæ febrilis* (Horner)). It develops very rapidly, making its appearance after the fever of the above-mentioned diseases has disappeared. It may or it may not be associated with herpes facialis or herpes labialis. This form of ulcer is without pain, but very intractable, usually lasting from four to twelve weeks. The corneal epithelium is the only membrane attacked; in this respect, the disease resembles an attack of herpes facialis or labialis, as in the latter disease the cuticle (epidermis) exfoliates, leaving a raw surface of the true skin. The absence of pain indicates a neuroparalytic affection. The exfoliation of the epithelium vesicles develops very rapidly. In one or two days a chain of vesicles appear, break down, resembling the denuded surface of the cornea after the removal of a foreign body by unskillful hands.

This plaque may remain without change for two weeks or more excepting a slight haziness of the surface; suddenly another area around the original ulceration may show desquamation, and this spot may rest quietly for two weeks, when again another outbreak may occur, until the whole of the epithelial layer is attacked. A drop of fluorescin solution aids materially in outlining the ulcer by giving the denuded surface a markedly green discoloration. An outbreak of the disease is usually preceded by conjunctivitis, coryza, and some pericorneal injection of the conjunctival blood-vessels which might easily be overlooked until after the ulcer had made its appearance. There is little or no pain, but slight inability to raise the eyelid. The complications arising may be suppurative keratitis, hypopyon, and iritis.

Treatment.—This should be local and constitutional. A mydriatic should be instilled to dilate the iris and put the eye at rest. Trichloracetic acid (10-per-cent solution) and tincture iodin are the best local remedies. After the ulcer has been outlined by the fluorescin solution, this area should be touched with either the acid or iodin on a cotton swab. Two drops of cocain or holocain should be instilled in the eye five minutes before the applications are made, as sometimes considerable pain is caused by these drugs, especially the acid. The applications should be repeated every second day until improvement is noted. The eye should be irrigated with a hydrastin, boric acid, or 1–5,000 sublimate solution, three times daily, and should be kept bandaged. In very painful ulcers castor oil, dropped into the eye, gives great relief.

℞ Olei ricini .... ℥ij; 12
Olei rosæ ....q. s.

Misce. Sig.: One drop in the eye every half hour until relief is obtained.

The nasal cavities should be examined and sprayed with an antiseptic wash. Then constitutional treatment should always be carried out: elixir of iron, quinin, and strychnin, mercury, etc., should be administered to maintain the general health.

Prognosis.—The ultimate disturbance of vision is in inverse proportion to the degree of normal restoration of epithelium.

ASPERGILLAR KERATITIS

SYNONYMS: *Mycotic keratitis; Keratomycosis aspergillina; Schimmelpilzkeratitis.*

This disease was first described by Leber in 1879, and subsequently studied by Berliner, Uhthoff, Fuchs, Wicherkiewicz, and others.

Etiology.—The disease is the result of an infection from the mold aspergillus fumigatus, entering where there is a denudation of the corneal epithelium. The affected area separates from the surrounding structures of the formation of a line of demarcation leading to the formation of a *sequestrum.* (See Plate III.)

Symptoms.—Intense pain, photophobia, and lacrymation are prominent symptoms. The diagnosis depends upon the dry appearance of the ulcer, its "crumbling-like" surface, circular line of demarcation followed by the formation of a sequestrum, which upon microscopical examination will show the mycelium of the Aspergillus fumigatus.

Treatment.—The treatment consists in removing the mass, and then treating the eye with mild antiseptic lotions.

FILAMENTARY KERATITIS

(*Fädchenkeratitis*)

This is a rare disease usually appearing after traumatism to the cornea or vesicular formations of that structure. Idiopathic cases have been described. The disease is characterized by the formation of small fine filaments from 2 to 4 mm. in length, one extremity being bulbous and the other attached to the cornea. The affection has been studied by Leber, Czermak, and others, especially Hess. The twisted appearance of the filaments has been ascribed as due to the movement of the lids.

GRILL-LIKE KERATITIS

(*Gitterförmige Keratitis*)

This latticelike distribution of corneal opacity was first described by Biber, Haab, and Dimmer. The latter author believes that the trellised lines are due to a folding of Bowman's membrane (*Zeitschrift für Augenheilkunde*, 1890, No. 2). A condition somewhat allied to grill-like keratitis is the nodular opacity of the cornea described by Groenouw, and subsequently studied by Fuchs, Chevallereau, and Treacher Collins. A family punctate degeneration of the cornea has been described by Fehr.

KERATITIS DISCIFORMIS

(*Disciform, Disklike, or Annular Keratitis*)

According to Fuchs, this disease deserves an individual classification. It is characterized by the formation in the middle layers in the cornea of a light-gray disk which is separated from

its margin by a sharply defined border of deeper gray. The corneal surface is often insensitive and dull. Rarely the epithelium breaks down. Generally signs of irritation are absent. The disease should not be confounded with other forms of deep or interstitial inflammation. It runs a chronic course and generally occurs in middle life. Treatment is of no avail in effecting a cure.

CORNEAL OPACITIES

A faint haziness of the cornea, the result of a previous inflammatory process, is known as a *nebula*. A spot of greater opacity, and of decidedly gray color, is called a *macula*. A mass of cicatricial tissue, of a decidedly white hue, receives the name of *leucoma*. These opacities may also be congenital.

Treatment.—A nebula resulting from recent ulcers may be largely cleared up by the application of an ointment composed of oil of turpentine, gtt. xx (1.2), and vaselin, 1 dram (4.0). Yellow oxid of mercury is also recommended, and electricity is

FIG. 81.—LEUCOMA OF THE CORNEA. (Magnus.)

said to be beneficial (Alleman). Vibratory massage and direct application of electricity with the corneal electrode are valuable procedures. In cases of central nebula an iridectomy performed behind a transparent portion of the cornea may be considered for the purpose of improving vision. If anterior synechiæ are present, they should be severed if any trouble arises from their presence. In certain forms of haziness and opacities of the cornea the author has had encouraging results from the use of massage by a special apparatus, injections of salt solutions, and

thiosinamine. The instillation of dionin (5 per cent) is also of value.

Transplantation of a rabbit's cornea has also been attempted by Von Hippel, and that of a chicken by the author, in cases where vision was destroyed by corneal opacity, but the results were not satisfactory, the transferred cornea becoming shrunken and opaque. Von Hippel's method consisted in making a circular incision in the cornea by means of an especially constructed trephine, after which the leucomatous material was carefully dissected from the membrane of Descemet. A portion of the animal's cornea is removed by the trephine and gently inserted upon the human cornea. The eye is then bandaged. Pick recommends

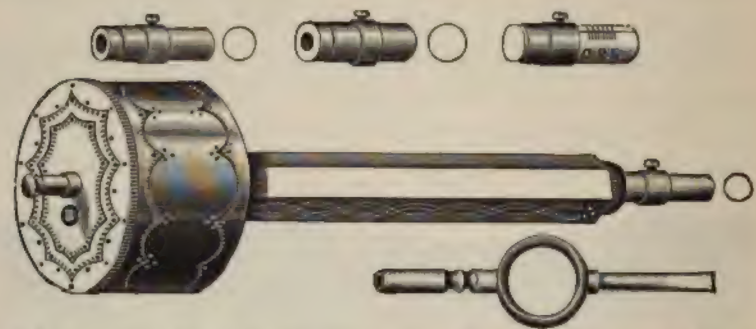


FIG. 82.—VON HIPPEL'S TREPHINE FOR CORNEAL TRANSPLANTATION.

the use of ammonium chlorid in the treatment of corneal opacities. He states that even old opacities improve very considerably. In fact, fresh opacities are not suitable for this treatment, and any congestion must be taken as a contraindication. The method of application is as follows: from 1 to 3 teaspoonfuls of the ordinary ammonium-chlorid solution is mixed in a cupful of boiled water. This is used in an eye bath for twenty minutes three or four times a day. Usually in the course of three or four weeks improvement is noticed. The application should cause no irritation, and may be continued for four to six weeks. Stronger solutions than the above act as irritants and do harm.

Tattooing of the Cornea.—When the operation is demanded by the patient from a purely cosmetic standpoint, tattooing yields very good results, even if the nebula is extensive. This operation was first introduced into ophthalmic surgery by Abadie and De

Wecker, of Paris, and may be successfully employed if the opacity of the cornea is permanent. If the cornea is very thin or the operation is likely to bring about intra-ocular irritation, tattooing is contraindicated. The operation is best performed in the following manner, after the eye has been prepared as in other operations:

Sepia ink, in stick form, is used in the operation, a piece of the India ink being rubbed down with sterile water into a thick paste, and then pricked into the cornea, which has been previously anesthetized by the local application of cocain. Excellent pigments have been prepared by Dr. S. Holth. These pigments are made in ivory-black, ultramarine-blue, earthy green, yellowish-brown, Naples yellow, yellowish-red, medium brown, dark brown, etc., and are prepared for use, extemporaneously, with a glass pestle. The best instrument for the purpose is a collection of four needles held together in a handle. The ink is placed on the cornea with a small spatula, and each impression of the instrument makes four pricks. The pricks should be numerous and the cornea *vigorously fanned* during the entire operation so that the ink will dry rapidly. It is also necessary to prevent the tears from collecting in the conjunctival *cul-de-sac;* if this occurs, they should be drained off with cotton. Both eyes are bandaged after the operation for twenty-four hours to prevent motion, at the end of which time the corneal epithelium has covered the scar and the pigment is thus protected. The eye is often very much irritated by this operation, as is shown by the slight pericorneal injection, which is, however, limited to the conjunctival vessels. In a few exceptional cases the operation is repeated to tone and round out the area of tattooing.

The author has obtained very gratifying results in the treatment of corneal opacities with the local application of electricity, as first suggested by Reute in 1853 ("Ophthalmologie," 1853, vol. i, p. 418). The positive pole is always applied to the affected area in oculomotor palsies, amblyopia, or amaurosis, with or without corneal opacities. Where there are corneal opacities without other ocular complications the negative pole is applied to the cornea. Electricity is contraindicated in cerebral congestion, organic brain disease, or irritation of the central nervous system, even if the ocular conditions call for its use.

Another most valuable procedure is that of ionic therapy, and while it is used for various ocular diseases, it is described here on account of its great value in corneal opacities. Wirtz, of Mülheim, has recently added a valuable procedure to ocular therapeutics, as described by P. Maxwell in the *Ophthalmic Review* as follows:

Ionic Therapy.—The introduction of ions into the body by means of electrolysis for a therapeutic purpose.

As early as 1846 Klenke claimed that he cured "scrofula" by introducing iodin into the system by means of electricity. From time to time other workers have proved that substances can really be introduced into the body by this method. Animals have been quickly killed by driving solutions of alkaloids through the skin by electricity, whereas the same solutions merely applied to the skin are quite inert.

Krüchmann, within the last few years, has treated syphilitic iritis and choroiditis by *iontophoresis*, using salts of mercury. In animals he was never able to detect any trace of mercury in the aqueous or vitreous, which is not surprising considering that mercuric salts are scarcely dissociated in solution. Nevertheless, his patients derived great benefit from the treatment.

In contrast to Krüchmann, who attempted to treat deep-seated diseases, Wirtz has confined himself to diseases of the superficial parts, the cornea, conjunctiva, and edges of the lids. He experimented with a number of different ions on the rabbit's eye and discovered what dosage is safe for the cornea and conjunctiva respectively. He then proceeded to test their efficacy in diseases of the human eye.

The theory of *iontophoresis* is shortly this. There are two kinds of electrical conductors: (1) Metals and metalloids; (2) solutions of salts, acids, and bases, which are called electrolytic conductors. Those of the first class are not chemically changed by the electric current, those of the second class are decomposed. In the case of salts the acid radicals appear at the positive pole and the basic radicals at the negative pole. The molecules in the rest of the solution appear to remain unchanged. Arrhenius has shown that when a salt like $NaCl$ is dissolved in water a certain proportion of the molecules is in a state of dissociation or *ionisation* as it is called, so that along with the mole-

cules of the undecomposed salt there are free ions of Na and Cl. These latter are exclusively the carriers of positive and negative electricity respectively. When electromotive force acts on the solution the ions of Cl (anions) with their negative charge, pass to the positive electrode and the ions of Na (kations), with their positive charge, to the negative electrode, and there give up their

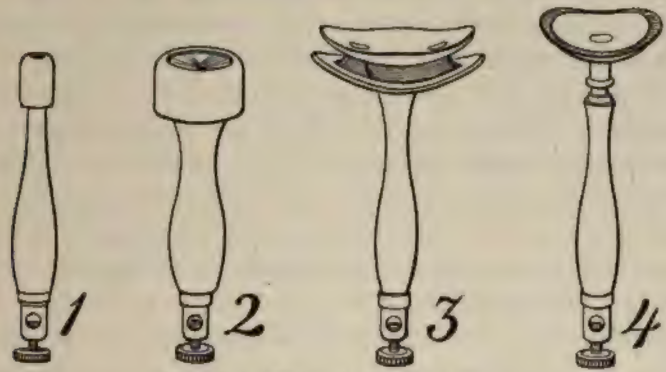


FIG. 83.—WIRTZ'S ELECTRODES.
1 and 2. Corneal electrodes. 3. Lid-margin electrode. 4. Conjunctival electrode.

charges, and are liberated in the free state. Hence the current does not bring about the decomposition, but utilizes it to give definite direction to the particles which are already separated.

In a solution of an acid like H_2SO_4 the H has a positive charge, and the acid radical SO_4 a negative one. Similarly in an alkaline solution like K O H the K has a positive charge, and the hydroxyl (OH) a negative one.

A substance which does not dissociate at all in solution is not an electrolyte and conducts no electricity. Further, the power of an electrolyte depends on the proportion of its contained molecules which dissociate.

The human body consists of tissues impregnated with saline solution, chiefly NaCl, and is therefore an electrolyte. If the two ordinary solid metallic poles of a battery are applied to the surface, the positive pole (anode) drives the Na to the negative pole (kathode), where by combining with water caustic soda and free hydrogen are given up. Conversely the negative pole drives the Cl to the positive pole, where in presence of water hydrochloric acid and free oxygen are formed. The fluid within the

body remains chemically unchanged. If, however, a solution of chlorid of zinc is placed between the positive pole and the surface of the body, zinc ions enter the latter and take up their position behind the sodium ions, already advancing to the negative pole; the longer the current acts the more deeply do they penetrate.

Any other kation can be introduced in the same way. If, however, it is desired to drive in an anion like iodin, the *negative* pole must be connected with the dissolved iodin salt.

Wirtz has found by experiment that: (1) the light metals Na, K, Li and the halogens Cl, Br, I act comparatively mildly, (2) the alkaline earths Ca, Mg and the acid radicals of sulphates and nitrates are more irritating, while (3) the hydrogen of acids and the ions of the heavy metals Zn, Cu, Hg, Fe, hydrosyl of alkalies (OH), and a few acid radicles, as of chromic and permanganic acid, are caustic.

The effect varies directly with the strength of the current and the time it is applied, and to a less extent with the strength of the solution. It must also be borne in mind that in a vascular tissue a large number of ions enter blood and lymph vessels and are carried out of the field, while in a nonvascular tissue like that of the cornea, there is naturally a more intense local action.

A large number of eye diseases are of an infective nature. The use of antiseptics as ordinarily applied has many disadvantages: (1) Their feeble power of penetration; they do not cure trachoma. (2) It is difficult to apply them locally; anything applied to the conjunctiva must also act on the cornea; even the actual cautery to be effective in a corneal ulcer must destroy some sound tissue. (3) It is not easy to regulate the dose.

Iontophoresis has none of these disadvantages. The living tissues of mammals have a higher resisting power than most of the pathological microörganisms. Iontophoresis in exact and careful dosage will enable us to destroy bacteria without permanent injury to the tissues.

It is very important that all drugs used should be chemically pure, and dissolved in distilled water. Solutions of ½ to 2 per cent are employed. The tears are an electrolyte, therefore the action of Cl or Na according to the pole has to be reckoned with. The ordinary action of cocain is much exaggerated when the

positive pole is used, it should therefore be sparingly applied and then well washed out with distilled water before applying the current.

The electrodes devised by Wirtz are very ingenious, but it is impossible to describe them properly without a diagram. Fig. 83 will give some idea. Layers of gauze impregnated with the desired solution are clamped into the necessary shape, while suitable shields protect the parts not to be treated.

Six cases of ulcer of the cornea were treated, three due to pneumococcus and three to diplobacillus. A ½-per-cent solution of zinc sulphate was employed, with a current of 2 milliampères for from 1 to 2 minutes. In 4 cases one application sufficed. In 2 a second was required. The resulting scars were transparent and the average vision $\frac{6}{10}$.

The eyes in 6 cases of interstitial keratitis were treated with iodin ions from a 1-per-cent solution of iodid of potash or with chlorin ions from a 9-per-cent solution of sodium chlorid, repeated about every 4 to 5 days. Radical results in such cases are not to be expected, but Wirtz considered them better than those obtained from the usual methods of treatment.

Three cases of macula corneæ were treated by chlorin ions with 2 to 3 milliampères for 3 minutes every 2 to 7 days. They had been treated with yellow ointment and dionin and the vision had become stationary. After iontophoresis a further considerable improvement was obtained.

In trachoma a ½-per-cent solution of copper sulphate was used with 2 to 3 milliampères for 2 to 3 minutes every few days. In 4 acute cases after 4 weeks the conjunctiva was "nearly normal," and 4 chronic cases were discharged cured, "as far as one can speak of cure in trachoma."

ARCUS SENILIS

SYNONYMS: *Gerontoxon ; Senile zone.*

A fatty degeneration of the margin of the cornea presenting a slight diminution in the translucency of its texture and assuming by degrees a smilar shape. There is, however, in many instances, a curvilinear interspace of clear cornea through which the iris may be seen, and which, according to Canton, although generally not involved, is not infrequently also implicated, espe-

cially where the arcus is quite broad. It rarely makes its appearance before the age of fifty, and is one of the physical signs of fatty infiltration. Professor da Costa, years ago, called attention in his lectures to this sign as associated with fatty infiltration of the heart, muscles, etc. The author has seen this opacity in very young people, but this was, no doubt, a remnant of embryonic arrest of development of the cornea and not a true disease.

According to Edward Canton, F.R.C.S., the cornea may be attacked by ulceration at the site of the senile zone, which follows ordinarily the upper segment. This ulceration, according to this author, when associated with *arcus senilis*, is usually found in persons who are gouty or rheumatic, or who have led irregular lives. The author has seldom encountered an ulceration of this character. In dark eyes, the opacity is more pronounced than in gray ones.

An arcus senilis does not interfere with the healing of corneal incisions in cataract operations.

DESCEMETOCELE

(Keratocele)

This is a protrusion from the cornea of that part of the membrane of Descemet that has formed the floor of a previous

FIG. 84.—RIGHT EYE DESCEMETOCELE. LEFT EYE, RUPTURE OF FLOOR OF ULCER FROM A BLOW.

ulcer. Treatment is of little avail. Sometimes touching it with a fine galvano-cautery will modify the course of the process. The opacity may vary from a thin line to 1 to 2 mm. in width, and in rare instances even wider.

TUMORS OF THE CORNEA

Tumors of the cornea may be either benign or malignant. To the former class belong dermoid and other cysts, fibroma, papilloma, and corneal " horns "; to the latter carcinoma, melanosarcoma (*very rare*), and epithelioma—the last being the most common, and, according to the usual selective affinity for location, in this instance also originates as a rule where the corneal and conjunctival epithelia merge. As far as endothelioma is concerned, J. Herbert Parsons is undoubtedly correct in stating that as there are no vessels in the cornea, the only endothelium is around the nerves. He describes such a growth of the cornea which must have originated in the limbus. Benign tumors may be removed with little danger of return. In the malignant forms it is frequently necessary to include the orbital contents in the operation.

INJURIES OF THE CORNEA

(*Keratitis traumatica*)

The importance of corneal injuries arises from the fact that opacities may result from even the most trivial, especially if neglected. The most common is that due to the presence of a foreign body. Foreign bodies removed by skilled hands with antiseptic precautions are attended with little disturbance, but attempts at their removal by means of a dirty penknife, toothpick, nail file, hairpin, or similar instrument without anesthesia of the cornea, give rise to an infected ulcer and a permanent opacity. The proper procedure in this class of cases is to irrigate the conjunctiva and cornea with a warm boric-acid solution, outline the denuded cornea by means of a drop of fluorescin, cocainize the cornea, and remove the foreign particle by means of an aseptic spud. (See Purulent Ulcer, p. 209, and Traumatic Ulcer, p. 211.)

POWDER BURNS

Powder burns, while belonging to the same class as the foregoing, require slightly different treatment. It is not advisable when there are a number of such burns of the cornea to attempt to pick off the grains of powder from the cornea with a spud;

the trouble is aggravated by irritating the already damaged cornea in this way. The face and eyes should be freely washed with hot water or with dilute peroxid of hydrogen (33 per cent). The latter solution will find its way into the wounds and by its reaction with the tissues will to a great extent dissect out the powder grains. A small pledget of cotton may also be used to remove the foreign bodies.

BURNS OF THE CORNEA

Burns of the cornea are rather common and may result from sudden contact with flame, hot ashes, curling iron, mineral acids, carbolic acid, caustic potash, caustic soda, lime, ammonia, etc. The prognosis in these cases is always doubtful, and in the case of those produced by the alkalies it should be withheld entirely for a period of three or four days following the injury. Alkali burns may be readily treated by applications of melted tallow, any oil, unsalted butter, vinegar, or molasses, substances at hand in every household. The patient should be placed in a darkened room so as to protect the eye from light. The condition of the cornea should be constantly watched, as the structure immediately after the accident may show little or no morbid change, yet in three days may undergo complete exfoliation.

In all extensive injuries of the cornea it is advisable to place the eye at rest by the instillation of 1 drop of atropin solution (1 grain (0.6) to 3 drams (12.0)). Both eyes should be dressed with sterilized vaselin and eye pads. This treatment should be repeated at the end of twenty-four hours. When the cornea is hazy, instillation of eserin (¼ grain (0.015) to 3 drams (12.0)) will aid in its preservation.

FOREIGN BODIES

Foreign bodies lodging in the cornea provoke an irritation, but pain is produced only when the cornea comes in contact with the conjunctiva of the eyelid. The object should be removed as quickly as possible under cocain by means of a cotton swab or aseptic spud and the wound treated according to antiseptic principles. Boric-acid lotion and similar solutions should be employed.

ANOMALIES IN THE CURVATURE OF THE CORNEA

CONICAL CORNEA

(*Keratoconus*)

A conical protrusion of the cornea anteriorly due to increased intraocular pressure and thinning of its central portion. The sugar-loaf appearance or conical distention of the cornea may be easily seen when the disease reaches a certain degree of development. The front of the eye has a peculiarly brilliant and sparkling appearance, and sometimes resembles a drop of clear water upon a convex glass surface. Viewed in profile, owing to the double refraction of light, the cornea appears dark between the apex and the base of the cone. When the eye is examined in a darkened room by means of the ophthalmoscope, one sees an interrupted wavy reflex instead of a clear red one. The point of light and shadow revolves around the base of the cone. This annular shadow is particularly characteristic, and attention was first called to it by Sir William Bowman.

Etiology.—The true cause is unknown, but in all probability it results from atrophic processes in the *cornea propria*, together with an increase in intraocular pressure inducing the bulging outward of the cornea.

Progress and Termination.—The disease usually makes its appearance from the fifteenth to the twentieth year, and is more common in females than males, particularly in those who are debilitated. The first symptoms are referable to the gradual loss of vision, which may remain stationary and again in a short time become more pronounced. Before visual acuity becomes diminished the patient will complain greatly of multiple vision, or *polyopia monocularis*. The disease often attacks both eyes successively, and yet the author has observed two cases in which but one eye was affected. The progressive myopia causes the

Fig. 85.—Conical Cornea.

condition to be easily confounded with true myopia, and is only distinguished by the results of an ophthalmoscopic examination or when trial lenses are used to improve the vision.

Diagnosis.—It may be confused with the distention of the cornea following keratitis, hernia of the cornea, partial staphyloma and true staphyloma, all of which show more or less deposition of inflammatory products, whereas the cornea is clear in keratoconus.

Treatment.—Internal medication is useless, it being impossible to restore the cornea to its natural form. Operative measures are sometimes employed. Various operations have been sug-

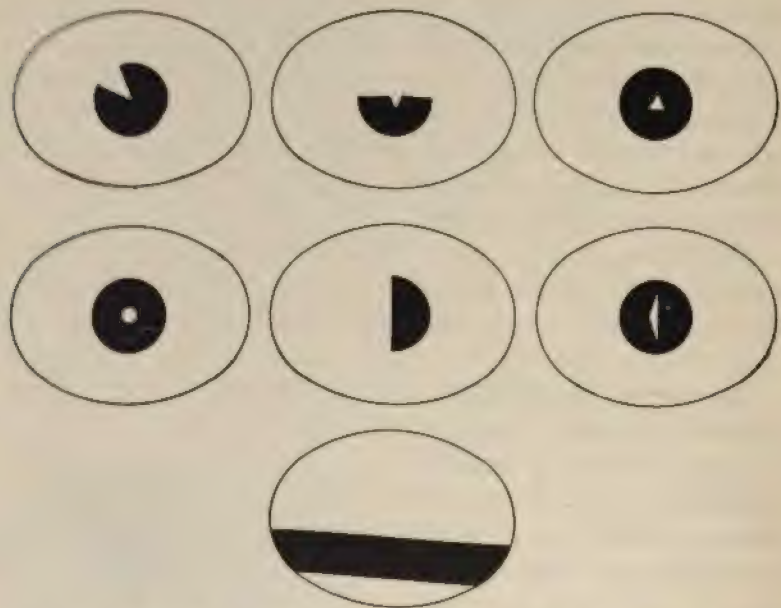


FIG. 86.—OPAQUE SLIPS FOR LENSES IN TREATMENT OF CONICAL CORNEA.

gested, among which may be mentioned the evacuation of the aqueous; removing a V-shaped piece from the cone and suturing the opening, removing a transparent crystalline lens (Adams); causing ulceration of the corneal apex by applying the solid stick of nitrate of silver (Von Graefe); applying the electro-cautery to the apex of the cone (Sir Anderson Critchett), and the making of an artificial pupil (Tyrrell). Robert D. Gibson penetrates the

cornea with the galvano-cautery and reports good results. Every operator has had some success with these procedures in flattening the cornea, but in all of these many operations considerable risk must be assumed. Tyrrell's method consists in making a puncture through the cornea with a small keratome close to the sclerotic, and then drawing out a small portion of the iris to bring the pupil from behind the apex of the cone. The iris is held in place by the cicatrizing wound. The author has had improvement in vision follow a small iridectomy and sclerotomy in several cases. The majority of American patients hesitate considerably before accepting the risk incident to any of the above operations named, preferring in most cases to bear the yoke of semiblindness.

Great benefit can be accomplished by cylindrical lenses (hyperbolic glasses) in improving vision. These have the disadvantage that in movements of the head the centers of the lenses fail to correspond to the pupillary centers, and their neutralizing effect is destroyed. Contact glasses have been suggested by the French ophthalmic surgeons, but proof is wanting as regards their practical efficiency. In one case under the observation of the author, in which the removal of an elliptical portion of the cone afforded some benefit, marked improvement was produced by a method suggested by the author and carried out in detail by the patient. A series of experiments extending over a period of several years were performed in an effort to adapt some form of disk that would permit rays of light to enter the eye through the least refractive portion of the cornea. The investigation began with a pinhole disk and stenopaic slit, and included the testing of every form of prism and patch until a satisfactory result was obtained. The conclusions reached were as follows:

1. That the character of the disk and its angle vary in each case.

2. That the intelligence of the patient is an indispensable adjunct in the selection of the necessary disk, as the method is almost entirely subjective.

3. That lenses in which the corneal area is screened by black patches of various sizes and shapes containing the requisite slits are better adapted for this purpose, and are less noticeable than prisms or ground glasses.

4. That the refraction of the cornea varies from time to time, requiring frequent examinations with changing of the disks.

5. That the incorporation of the patches with the correcting lenses gives rise to an additional improvement.

6. That the only disadvantage lies in the fact that the patches do not correspond to the cornea during ocular movement, but this is compensated for by the marked improvement and comfort afforded when the eyes and disks are adjusted for some average range.

7. That a fair trial should be made with these disks before resorting to operative procedure.

In other cases this method has been employed with very gratifying results, but in this particular case vision was brought to $\frac{6}{9}$ and $\frac{6}{12}$, and work at close range was comparatively easy when a disk with a smaller aperture was employed.

The quotation, in part, of this patient's letter describing this procedure is as follows:

"Of these small black opaque disks I find the one with the round opening to serve my purpose best, for distance as well as for reading, when used in front of the left eye. To this particular disk I have devoted much time and attention, having experimented with a number of different sized openings—round and otherwise—in order to find the 'happy medium' for all needs and requirements, and I know I have found it in this size. It serves me well on plane glass, and remarkably well when used in connection with the 9 D concave cylinders. So much for the left eye.

"Now, as regards the right or near-sighted eye of mine, I obtain the best results for this eye with the half-disk which has the small V cut into the center of same, for reading purposes, and at the same time answers quite well for distance, but then only in twilight and not otherwise. As you will notice, this latter, or V-shape, is a part of and has the same dimensions as the 'triangle' disk, and to which I have also given a great deal of attention and experimented with various sizes before finally deciding on this as being the best for the purpose—reading—and which I find especially so when used in conjunction with the 9 D cylinders.

"As to the remainder of the disks, they all have their special merits, though the above mentioned seem to be about the best,

and as near perfection for my case as I believe it is possible to get them, and I must confess I am very well satisfied with the results thus far obtained, and sincerely hope that they may yet be the means of benefiting others equally as much as they have myself through your efforts in this direction."

GLOBULAR CORNEA

SYNONYMS: *Keratoglobus; Anterior hydrophthalmia; Buphthalmos; The eye of Juno.*

A general spherical distention of the cornea—a rare form of dropsy of the anterior chamber. The iris and cornea are enlarged, but the tension and fundus appearance are normal. Hyperopia is present and visual acuity is normal. It may simulate infantile glaucoma, but careful examination will serve to make a distinction. The *prognosis* is unfavorable.

Treatment.—Sclerotomy and repeated paracentesis are suggested.

KERATECTASIA

The term applied to the undue protrusion of an opaque cornea as the result of some inflammatory condition unattended by per-

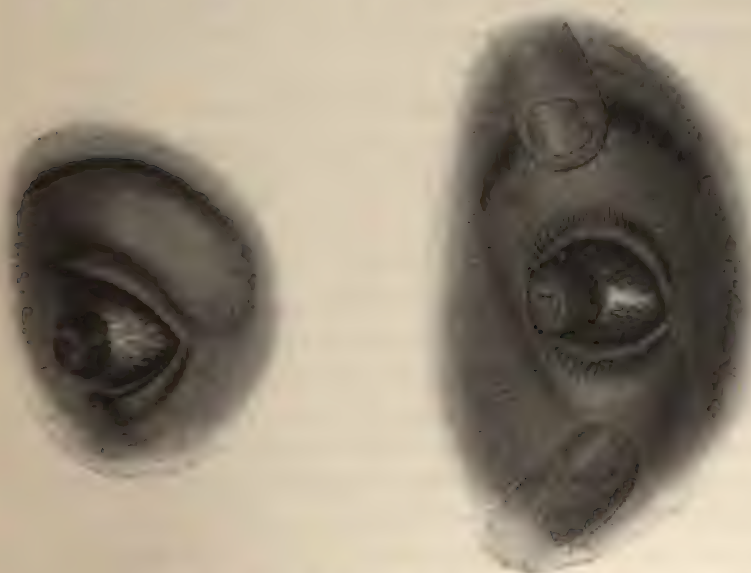


FIG. 87.—STAPHYLOMA OF CORNEA.

foration. The iris remains unaffected, thus distinguishing the condition from a staphyloma of the cornea.

STAPHYLOMA

This is a protrusion of the eyeball anteriorly or posteriorly as the result of weakening of its structures. Anterior staphyloma usually consists in protrusion of an opaque cornea, together with the iris or the sclera alone. It most often follows gonorrheal conjunctivitis.

Treatment.—Three modes of treatment suggest themselves in the following order: (1) sclerotomy, (2) Critchett's ablation, (3) enucleation.

PIGMENTATION OF THE CORNEA

BLOOD PIGMENT

Blood pigment is occasionally deposited in the layers of the cornea around the sclerocorneal margin, causing it to assume a brownish color. This condition is most frequently observed after hemorrhage into the anterior or posterior chambers. The blood is carried by the minute lymph streams to the cornea, where it is broken up into its component parts. This disintegration requires a period of from one to four weeks, after which the pigmentation undergoes very gradual absorption. One case of Treacher Collins took two and one quarter years, and according to this authority, hematoidin is the chief constituent of the deposit.

ARGYROSIS

Argyrosis in connection with the cornea has been described. Knies describes marked pigmentation of the membrane of Descemet, the other portions of the cornea being exempt.

Other metals (copper, iron, etc.) may also stain the cornea. Superficial deposition of lead salts have followed the application to the eye of lead water and laudanum where there coexisted denudation of corneal epithelium.

CHAPTER VIII

DISEASES OF THE SCLERA

GENERAL CONSIDERATIONS

THE sclera or external coat of the eye is not as liable to disease as are the other portions of the eye. Its tough, fibrous structure and the scarcity of blood-vessels seem to protect it from acute inflammation particularly. The loose connective tissue that separates it from the conjunctiva and capsule of Tenon is known as the episcleral tissue, and is comparatively rich in blood-vessels, being thus predisposed, to a certain extent, to inflammatory conditions. Disease limited to the sclera alone is not common, it being more frequent to find such conditions associated with morbid affections of adjacent ocular structures.

The principal affections to which the sclera is liable are inflammation, staphyloma, and injuries.

INFLAMMATIONS

Inflammation of the sclera may be either superficial or deep, according to the structure involved. Superficial scleral inflammation is limited to the episcleral tissue, and is known as episcleritis.

EPISCLERITIS

This is inflammation of the subconjunctival connective tissue, and consists of a circumscribed inflammatory area (" nodule ") upon the sclera with or without any accompanying deep inflammation. It is essentially a superficial scleritis.

Etiology.—Episcleritis may arise as a secondary affection, and in such cases it is usually associated with inflammation of the anterior segment of the eye. Under these circumstances it is often impossible to distinguish it from the causal condition. Occurring

as a primary affection, episcleritis may in most cases be traced to some constitutional affection, such as gout, rheumatism, and syphilis. The condition seldom attacks children, being restricted almost entirely to adults. It is somewhat rare in this country. In the Medico-Chirurgical Hospital service the proportion is about 1–3,000, while at Moorfield's Eye Hospital London, the proportion is about 1–700 (author's statistics). The frequency with which it attacks women is rather interesting, as most of these patients are nursing mothers or are the subjects of some uterine affection. A satisfactory explanation of this observation has not as yet been advanced. Episcleritis is also said to arise from digestive disturbances, disturbances of muscle equilibrium, and eye strain.

Symptoms.—The most prominent symptom is the well-defined area of reddish-violet or purplish hyperemia of the swollen episcleral tissue due to injection of the ciliary, deep pericorneal, and conjunctival vessels. This peculiar congestion shows a marked tendency to extend around the corneoscleral margin.

It usually involves but one eye at a time, and runs a very chronic course, extending over a period of four to eight weeks or more, although a fugacious form has been described by Fuchs that lasts but a few days and recurs at regular periods. Both eyes may become the subject of this disease, but an interval of one or two years usually elapses between the attacks in each eye.

The affected spot is always decidedly prominent, and its peculiar purplish discoloration is particularly characteristic. There is tenderness to touch and more or less constant pain and discomfort in the eye. The iris is always discolored and sluggish, although no iritis is demonstrable. Photophobia and lacrymation may be present. The pressure of very small areas of episcleral inflammation may be mistaken for phlyctenules, but the vesicular character and ulcerative tendency of the latter will aid greatly in making a distinction. The eye affected by this disease is usually incapacitated for near work. The course of the average case of episcleritis is subacute, reaching its height in the course of three or four weeks, but the swelling and purplish discoloration may persist for several months. Relapses and recurrences are not uncommon.

Treatment.—In those cases in which the presence of a particular constitutional affection is obvious, the appropriate medication should be prescribed, pushed to the point of tolerance. Often, for various reasons, it is impossible to elicit information or to detect symptoms concerning these disturbances, and in these patients the administration of mercury and chalk, salicylates, or iodids, alone or combined, is advisable. The salicylate and iodid of strontium have been well recommended in this condition. Diaphoresis and free purgation should never be neglected as routine measures, as they are productive of no harm, and often give rise to considerable benefit. The administration of the alkalies in addition is a very useful procedure. The following formula has been employed by me in this condition over a period of several years with most excellent results:

℞ Sodii hyposulphitis	ʒiij;	12
Tincturæ zingiberis	ʒijss;	10
Aquæ chloroformi	℥ij;	60
Aquæ anisi	℥viij;	240

Misce. Sig.: Tablespoonful after each meal.

The late Shadford Walker, F.R.C.S., Liverpool, England, suggested and used extensively in episcleritis in females the following formula:

℞ Decoction aloes comp.............	fl ℥ij;	60
Misturæ ferri compositæ..........	fl ℥viij;	240
(Griffith's iron mixture.)		

Misce. Tablespoonful in water three times daily, after meals.

This formula has also given me most gratifying results. My attention was first called to it by Mr. T. Herbert Bickerton, the successor and former assistant of Mr. Walker.

The local treatment consists in the application of sedative eye lotions. Massage of the eyeball through the lids with the ointment of the yellow oxid of mercury should also be employed. A 5-per-cent solution of dionin is frequently of value. Scarification of the swelling and scraping of the tissues to the healthy sclerotic is a radical measure, but is most efficacious. Leeching of the temple by means of the Heurteloup leech should be per-

formed in order to relieve the attendant pain. Atropin (1 grain (0.06) to the ounce (30.0)) should be instilled to place the iris and ciliary body at rest. It also serves to lessen any tendency toward corneal involvement. The constant current, from 2 to 2.5 milliampères, by means of the hydro-electric eye bath is a valuable measure.

Prognosis.—The disease is very obstinate to treatment and frequently recurs after a cure has apparently been effected. As a sequel of the disease there may be atrophied areas of the sclera, especially around the corneoscleral margin. The inflammation may extend to the cornea, producing slight opacities, or may even cause blindness by extensive corneal opacities. The iris and ciliary bodies may also become involved, and give rise to an iridocyclitis.

EPISCLERITIS PERIODICA FUGAX (FUCHS)

SYNONYMS: *Episcleritis partialis fugax; "Hot eye"* (Jonathan Hutchinson).

This variety of "relapsing" episcleritis, to which v. Graefe gave the name of *subconjunctivitis*, is characterized by the appearance and reappearance of episcleral injection at intervals varying from several weeks to months. It occurs chiefly in adults with rheumatic and gouty diatheses.

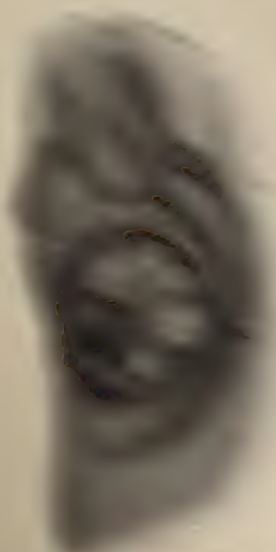
Treatment is that of the underlying cause. Aspirin and local massage have been found of value. The treatment is essentially that of episcleritis.

SCLERITIS

Deep inflammation of the sclera is known as scleritis, and affects the external layers, together with the subconjunctival tissues. It may be accompanied by kerato-iritis.

Etiology.—The condition is generally observed in young adults, and is most commonly met with in gouty or rheumatic individuals. It may also be associated with syphilis, disturbed menstruation, exposure to cold, influenza, and gout. Scleritis frequently occurs in mothers, due to lactation; this would seem to indicate a relation between the disease and a disturbance of the general nutrition.

A knowledge of this fact is of great value in planning the treatment, which is essentially tonic in character.



BUPHTHALMOS

SYNONYMS: *The Eye of Juno; Hydrophthalmos; Congenital glaucoma.*

This condition, which is generally observed in childhood, usually depends on a congenital failure of the angle of the anterior chamber to open, as it does in the course of normal development. This causes increased tension, which, in the developing eye, results in a gradual distention of all its coats. It may also be secondary to glaucoma.

The globe is enlarged in all its diameters; the cornea becomes very prominent, comprising about one third of the outer tunic. The sclera has a bluish tint on account of its thinning. The lens remains small and is loosely attached; the optic disk becomes cupped and gradually deteriorates; the anterior chamber is deep and filled with aqueous fluid; and the diameter of the iris is much beyond the normal.

Diminution of vision, nystagmus, pain, and photophobia are symptoms accompanying this condition.

Treatment.—Prolonged use of a myotic (eserin, $\frac{1}{2}$ grain to 3 drams) may assist in retarding the disease, but as it only gives temporary relief, a sclerotomy or iridectomy should be performed as soon as possible. The prognosis is not favorable, and parents must be warned as to the ultimate loss of vision.

INJURIES OF THE SCLERA

The sclera is subject to incised, lacerated, and punctured wounds, all of which may be infected or noninfected in character. Noninfected wounds are the least dangerous, and heal rapidly. Infected wounds, on the contrary, nearly always induce panophthalmitis. Although the sclera may be injured by traumatism applied in various ways, it usually receives its injury from the entrance of foreign bodies.

Foreign bodies which partially penetrate the sclerotic should at once be removed with delicate forceps. Small fragments of glass are the most difficult to remove, since they pass through the conjunctiva and find lodgment in the sclerotic. The only way to remove the glass, which is generally invisible, is to locate it by gentle pressure, grasp the conjunctiva, raise it, and cut out con-

junctiva and episcleral tissue with curved scissors. This sometimes is all that is necessary; if the glass is buried in the sclerotic it can then be taken out with delicate forceps. Foreign bodies that escape the ordinary methods for their detection may be located by the X-ray, or the magnet in the case of metallic particles. (See chapter on Foreign Bodies.)

In cuts of the sclerotic, with escape of the vitreous, it is best to cut off the band of vitreous and apply a pressure bandage; or, if the wound is very extensive, ½ to 1 cm. of the conjunctiva and episcleral tissue may be drawn together by a suture.

Rupture of the sclerotic from a blow is always serious, not only on account of the wound to the sclerotic, but also on account of the danger to the choroid, and the possibility of intraocular hemorrhages. In cases of this character the eyeball should be removed. An unusual case recently came to the author's notice, where a woman ruptured the sclera from running into the edge of a door.

In all scleral injuries the wound should be freely irrigated and antisepticized by boric-acid solution (10 grains to the ounce) or bichlorid-of-mercury solution (1–5,000), and a firm pressure bandage applied. Rest in bed should be advised, if practicable. Iced compresses should be employed to reduce any inflammatory action. In wounds of the sclera alone, in which there are clean wound margins, sutures may be introduced. If the margins of the wound do not show a tendency to unite, they should be stimulated with the nitrate-of-silver stick, or, of necessary, by the actual cautery.

Among the very rare morbid conditions of the sclera may be mentioned abscess, ulcer, gumma, tubercle, fibroma, sarcoma, enchondroma, and pigmentation of the sclera.

CHAPTER IX

DISEASES OF THE IRIS AND CILIARY BODY

GENERAL CONSIDERATIONS

THE iris and ciliary body form the anterior portion of the uveal tract or vascular coat of the eye, the remaining portion being formed by the choroid. The close connection of these structures is such that when one portion is diseased the remaining portions are liable to participate in the morbid process. The function of the iris and ciliary bodies depends largely upon their vascular structure, and this latter predisposes toward inflammatory conditions. Inflammation is the most common affection, and is attended by enormous dilatation of the vessels in the affected and adjacent structures and is manifested externally by the peculiar deep ciliary injection. The functional activity of the iris and the ciliary body is suspended and the color of the iris becomes changed. During the progress of this affection adhesions form upon the posterior surface of the cornea or anterior surface of the lens which, if left intact, greatly limit the motion of the iris, and change the shape and size of the pupil. These adhesions are known as *synechiæ*. A somewhat similar condition is produced during fetal life by the presence of a thin transparent membrane. This is known as the pupillary membrane and normally disappears by absorption about the seventh or eighth fetal month, and is of importance in determining the age of infants prematurely born. The iris may also be the seat of functional disturbances, traumatism, and neoplasms.

CONGENITAL ANOMALIES OF THE IRIS

Persistent Pupillary Membrane.—The pupillary membrane may occasionally persist after birth. The most common variety is in the shape of a single fine thread, one end of which is at-

tached to the lens anteriorly, the other to the iris. Several strands may coexist, either individually or united. They are differentiated from posterior synechiæ by the fact that they do not interfere with the normal function of the iris (pupillary reaction).

Pigment alterations are comparatively frequent. The iris pigment may be grouped or scattered throughout each iris or the tints may differ. *Heterochromia* is the term applied when the color of one iris is normally different from that of the other iris. A difference in color may also follow diseased conditions of this structure. An absence or marked diminution in pigment is observed in albinos, in whom the iris appears pink, due to the reflex of the fundus shining through it.

Alterations in position are rather common and deserve passing notice. An eccentric position of the pupil downward and to the inner side is normal, but this may be markedly exaggerated, and is then known as *corectopia* or *ectopia pupillæ*. It may be symmetrical, and is sometimes seen in several members of the same family.

Aniridia (*irideremia*).—Absence of the iris is a very rare congenital defect. In this condition, which is frequently hereditary, the iris may be partially or completely absent in both eyes. Nystagmus, dimness of vision, photophobia, and opacities of the cornea are common accompaniments.

Fig. 90.—Coloboma of Iris and Lens. (Author's case.)

Multiplicity of the pupils or **polycoria** is an ophthalmological curiosity. It is seen most frequently as the result of traumatism. In these cases only one of the openings responds to light or is influenced by drugs. In Schapringer's case there were four apertures.

Coloboma of the iris is a cleft or fissure usually extending downward and inward (although it has been observed upward and outward, upward and inward, as well as outward)

and resembling an imperfect iridectomy; unless exceptionally extensive it does not interfere materially with vision. It may be associated with coloboma of the ciliary body or choroid. Coloboma is usually monocular.

Functional Disorders of the Iris.—The most frequent functional disorders of the iris are *mydriasis, myosis,* and *hippus.* These have been described in the chapter on The Pupil in Health and Disease, to which the reader is referred.

Iridodonesis.—The most frequent cause of iridodonesis or tremulous iris is the total absence of the lens, or its partial or complete dislocation. In some cases the condition is congenital. In cases due to luxation of the lens the iris oscillates when the eye is moved in different directions; when the lens is only partially dislocated the tremulousness will be confined to that portion of the iris which has lost the support of the lens. The condition is also observed in those cases in which the anterior chamber of the eye is enlarged and the iris is stretched sidewise, the support of the lens thus being lost.

INFLAMMATIONS

Hyperemia of the iris always precedes iritis, but in addition it may be associated with inflammation of neighboring structures, as in conjunctivitis, keratitis, scleritis, traumatic conditions, etc.

Symptoms.—It is characterized by a change in the color of the iris; usually it changes to green or reddish brown, according to the original color. The deep pericorneal vessels are enlarged coincidently. The pupil is contracted, and its reaction to light and accommodation is extremely sluggish. Synechiæ do not form in simple hyperemia, and resolution occurs unless inflammation follows.

Treatment.—The instillation of atropin in addition to the measures indicated to combat the causal affection usually suffices to bring about the normal condition of the iris.

IRITIS

Inflammation of the iris is the most frequent affection to which this structure is liable, and is always preceded by hyperemia.

Etiology.—It may arise as a symptomatic affection in the course of syphilis, gout, rheumatism, diabetes, tuberculosis, gonorrhea, etc., or it may occur as the result of extension of inflammation from adjacent ocular structures. It is also due to traumatism, exposure to cold and wet, febrile diseases, new growths, etc. Dental caries has also been recorded as a causal factor in iritis. The disease is sometimes encountered as an idiopathic affection.

Symptoms.—The symptoms and signs of the various forms of iritis vary more or less, according to the character and intensity of the inflammation, but on the whole are rather constant.

The manifestations of iritis may be considered as objective and subjective. These vary more or less, according to the character and intensity of the inflammation, but on the whole are rather constant.

The objective phenomena are mostly referable to the changes in the iris itself, and include alterations in its color, similar to those seen in hyperemia, but exaggerated in intensity; contraction with sluggish and irregular movements of the pupil; adhesion of the iris to the lens capsule as demonstrated by the instillation of atropin; *synechia,* a morbid adhesion of the iris to the cornea—*synechia anterior,* or to the anterior capsule of the lens—*synechia posterior.* The synechia may be partial or total, together with punctate deposits on the posterior layer of the cornea, changes in the equeous humor and anterior chamber, including turbidity, hypopyon, hyphemia, and fibrinous exudates. The depth of the anterior chamber may be greater than normal, especially with complete annular posterior synechia, and the intraocular tension may be increased. Externally, there is present marked pericorneal injection involving the deeper ciliary vessels. There is also conjunctival congestion, but this is more superficial and movable than the pink zone of iritis. (See Plate III.)

Conjunctival Injection	*Ciliary Injection*
Present in diseases of the conjunctiva.	Present in diseases of the iris, ciliary body, and cornea.

Conjunctival Injection	*Ciliary Injection*
Derived from posterior conjunctival vessels.	Derived from anterior ciliary vessels from perforating episcleral branches.
When the eyelids are pressed on the bulbar conjunctiva, and the latter moved, the congestion also shifts its position.	Remains stationary when conjunctiva is moved.
Most marked at and near fornix, fading as cornea is approached.	Most marked immediately around the cornea, fading as the fornix is approached.
Color of injection is a vivid red.	Color of injection is pink, violaceous, or lilac.
Texture of vessels, coarse.	Texture fine.
Usually associated with mucopurulent secretion.	Usually not accompanied by abnormal secretion.

The subjective symptoms include neuralgic pain distributed over the course of the fifth cranial nerve, and worse at night; more or less tenderness on palpation over the ciliary region; photophobia, lacrymation, tiring of accommodation, diminution in the acuity of vision, malaise, fever, and nausea.

Varieties.—According to its course, iritis may be divided into acute, subacute, and chronic. Acute cases require several weeks to complete their course, but recurrences are frequent and the affection is likely to become chronic. One or both eyes may be attacked; usually the disease begins in the second eye when it is subsiding in the first. Iritis may be primary or secondary; finally, it may be congenital or acquired.

Iritis may also be classified, according to its pathology, as simple or plastic and parenchymatous or suppurative. The term "serous iritis" is now considered a pathological misnomer, and will be discussed under its proper classification—"serous cyclitis."

Plastic Iritis.— Simple or plastic iritis is the most frequent form of the affection encountered. (The term plastic has been applied on account of the synechiæ which generally form.) It is characterized by marked ciliary and pericorneal congestion; slight

edema of the subconjunctival tissue; haziness of the aqueous; discoloration of the iris; contraction and immobility of the pupil; *posterior synechia* (adhesions of the iris with the anterior capsule of the lens). The pupil seems to be rolled under, and this appearance is best seen by the aid of a corneal microscope. This type of the disease is also distinguished by the pouring out of the exudate into the pupillary space, forming a false membrane in that area. Occasionally the exudate consolidates and is deposited as a gelatinous mass in the bottom of the anterior chamber. In mild cases it may be entirely absorbed.

Etiology.—In from 30 to 60 per cent of cases this affection can be directly traced to acquired syphilis. Of the remaining cases a large number are attributed to extension of inflammation of the cornea, sclera, ciliary body, choroid, etc. Injury, infectious fevers, rheumatism, etc., are also causes. It may occur without obvious cause.

Course.—It may be acute, subacute, or chronic. A case may be acute and run its course within a few weeks with total absorption of the exudate and complete return to normal. Such cases are rare, however, and the most frequent termination is the leaving behind of adhesions or opacities upon the anterior lens capsule. As a primary result vision is always impaired, but more serious consequences may follow the changing of these adhesions into contracting connective-tissue bands. These adhesions not only serve to limit the movements of the pupil, but are a source of constant irritation, tending to induce recurrences upon the most trivial cause. Total occlusion of the pupil or total synechiæ may be produced, and as an ultimate result secondary glaucoma and blindness may occur.

Treatment.—As the most frequent constitutional disturbances inducing this disorder are syphilis and rheumatism, the general treatment should be directed toward either or both affections, as they frequently exist combined. Mercury should also be employed to its physiological limit for its antiphlogistic effect in the form of hydrargyrum cum creta, 2 grains (0.12) to 4 grains (0.24) three times daily. Venesection—abstracting from 10 to 15 ounces of blood from the arm—repeated, if necessary, is often of great use.

The local treatment is of utmost importance, as the danger of

the disease lies in the formation of adhesions, and these can readily be prevented by prompt and appropriate local measures.

Atropin (4 (0.25) grains to the ounce (30.0)) should be instilled every three hours until mydriasis is complete, after which it may be employed less frequently. This procedure not only dilates the pupil, but places the ciliary muscle at rest and relieves the pain in part. Leeching of the temple by means of Heurteloup leech or leeches diminishes the congestion and lessens the pain considerably. The application of hot moist compresses has an additional anodyne effect.

Subconjunctival injections of corrosive sublimate, normal salt solution, dionin, etc., have been recommended by various ophthalmologists. The injection of salt solutions combined with the ordinary treatment seems, in my experience, to be singularly effective, but the manner in which its effect is brought about is not clear.

Dr. Wessely's experiments with subconjunctival injections of salt solutions were made upon rabbits, and the results were carefully observed. He concludes that these injections do not act through their osmotic power upon the internal humors of the eye, since analyses have proved that their penetrating power is very small, that they do not produce their effect as lymphagogues, nor so far as regards sodium-chlorid injections by any direct action in setting free leucocytes. They really act by powerful local stimuli to the conjunctiva, and even when frequently employed have no injurious effects. The nerves of the conjunctiva thus energetically stimulated act in a reflex manner, presumably through the vasomotor nerves in the vessels of the adjoining vascular territory, leading to dilatation of the ciliary area. The hyperemic condition of the ciliary vessels renders their walls more permeable, and the result is the secretion of aqueous humor containing much albumin, in place of the normal aqueous, which contains none. Dr. Wessely then passes to a consideration of the therapeutic value of these injections, and observes incidentally that the accompanying processes of inflammation, particularly edema, have long been regarded as safeguards to the organism without any particular reasons. Bacteriological researches have, however, shown that the serum of normal blood contains several protective materials which play an important part in the strife against the

lower organisms, and that these materials, to which the names of *bacteriolysin*, *agglutinin*, *hemolysin*, and *precipitin* have been applied, are in all probability associated with the albumin of the serum. The question immediately arose whether as the normal aqueous humor is almost destitute of albumin, while that secreted after subconjunctival injections contained a notable proportion of albumin, the beneficial effects observed might be due to the presence of ferments, enzymes, or solvents eliminated with it. Experiments made with animals rendered immune with the blood of an ox showed that the normal aqueous humor has no power of dissolving bovine blood corpuscles, and hence contains no hemolysin. But if a subconjunctival injection were made of a 5- to 10-per-cent solution of common salt, and after the lapse of half an hour the aqueous was withdrawn, it quickly dissolved an equal volume of a 5-per-cent mixture of blood corpuscles—a very interesting result—and still other experiments demonstrated clearly that the power of solution in the newly secreted aqueous was in direct proportion to the amount of aubumin that the fluid contained.

PARENCHYMATOUS IRITIS

Parenchymatous iritis may be *suppurative*, *gummatous*, or *tubercular*, and is characterized by marked cellular proliferation within its tissues, causing the iris to assume a swollen or nodular appearance. When localized, small yellowish nodules may be seen in the membrane, but when generalized the entire iris is swollen and discolored yellow and the margin of the pupil is bound down to the capsule of the lens. The congestion is so intense that frequently by the aid of a convex lens it is possible to distinguish the vessels of the iris. Occasionally these vessels rupture and there is an extravasation of blood in the anterior chamber. A more common occurrence is the deposition of pus cells from a purulent effusion in the parenchyma of the iris, in the anterior chamber constituting *hypopyon*. This purulent exudate in the anterior chamber is fluid in character and changes its position with the movements of the head, thus distinguishing it from the hypopyon that attends *ulcus serpens* of the cornea. It is freely absorbed, and its duration, therefore, may be but twenty-four or forty-eight hours. Recently a case came under the au-

thor's observation in which the entire anterior chamber was filled with pus and caused the cornea to appear as if infiltrated. The lids were swollen and edematous, and there was great occipital pain. Distortion of the pupil is a constant accompaniment of this form of iritis. The most frequent cause of the suppurative variety is wound infection (perforating wounds and ulcers). It may also be an expression of metastasis (metastatic ophthalmitis.)

Etiology.—Syphilis.—The later stages of syphilis are frequently manifested by parenchymatous inflammation of the iris. This may be indicated by the formation of one or more yellowish or reddish-brown nodules in the iris tissue situated at either the pupillary or ciliary border. The inflammatory changes are distinctly localized to these nodules, the intervening tissue being unaffected. No scarring is left behind after their absorption, but pigment may remain. This condition may be considered as of the papular type of syphilis. Gumma of the iris is less frequent and is a solitary nodule, and generally is situated at the pupillary or ciliary margin. It appears with greatest frequency at the ciliary border and rapidly breaks down and discharges its contents, to be replaced by connective tissue. Syphilis is also responsible for some cases of diffuse parenchymatous iritis.

Tuberculosis may also be manifested by tubercles in the parenchyma of the iris. The latter is extremely rare. In the former variety, however, the nodules are of a pale-yellow color and situated at some distance from the edge of the iris in its lower half. These nodules occur in groups, and there is associated with them tubercular changes in the adjacent lymphatic glands. There are no symptoms of acute inflammation, and hypopyon is seldom if ever seen. Young persons in whom other tubercular manifestations may be detected are most frequently attacked. There may also be confluent tubercles, with tendencies to spread, and causing rapid destruction of the eye.

In some cases the nodules are absorbed. Removal is usually not successful. Injections of tuberculin have been employed by von Hippel and others. The literature on this subject has been ably worked up in the article of William E. Gamble and E. V. L. Brown (*Jour. Am. Med. Assoc.*, October 14, 1905), together with their personal experiences.

Diabetes is also responsible for a small number of cases of parenchymatous iritis, particularly those intractable forms that occasionally follow cataract extraction. Microscopical examination has shown edema of the pigment layer and general "sponginess." Marked exudation often occurs in this variety.

Gonorrheal affections of the uveal tract may consist of iritis, mild or severe iridocyclitis, or iridochoroiditis. They are conveniently described under this chapter on account of the anatomical intimacy of the structures involved.

Etiology.—Why the gonococcus should have a selective affinity for the uveal tract has not yet been satisfactorily explained. The inflammation caused by the gonococcus does not materially differ pathologically from that caused by other agencies. The negative bacteriological finding, as stated by Byers, may not be conclusive of the organisms not having been present, or, on account of the difficulty in detecting them, they may have been overlooked. With a full realization of the extreme difficulties in detecting bacteria within the eye, the author rather leans toward the toxic theory of the inflammation. The subject has been well studied since Sir William Lawrence described the subject clinically in his "Treatise on the Venereal Diseases of the Eye." Mackenzie's description is classical. Morax, Bull, Kipp, Coppez, Panas, Nettleship, Lawford, and numerous others have since recognized and described the affection.

Symptoms.—The symptoms are essentially those of iritis, which may be mild or associated with severe iridocyclitis or even plastic iridochoroiditis. The symptoms usually occur late, when the gonorrheal poison has already become generalized throughout the system. According to Byer's statistics, the affection predominates in the male and, moreover, during the period of greatest sexual activity, or from twenty to forty years of age. Metastatic iridocyclitis and conjunctivitis may coexist (Kurka, *Wiener klin. Woch.*, vol. xv, p. 1032).

Treatment.—Atropin, soothing collyria, and hot compresses are indicated locally. Gonococcic serum should be tried. (See author's cases of Metastatic Gonorrheal Conjunctivitis.)

Rheumatism, in the sense of the acute rheumatic fever, has not yet been definitely proved to be a cause of iritis, although the association of affections of the joints and iritis is not un-

common. Poynton and Paine succeeded in producing an acute iritis in rabbits after intravenous injections of the "diplococcus rheumaticus," but which, as Parsons states, was probably a septic iritis frequently seen after the injection of virulent pyogenic organisms.

Symptoms.—One eye at a time is generally affected. There may be considerable pain and tenderness of the eyeball. This variety usually occurs between the ages of twenty-five and fifty. *Numerous* but *small* posterior synechiæ are rather characteristic of this form of iritis. Relapses are very common. It may occur without accompanying rheumatic symptoms elsewhere.

Treatment.—The salicylates should be freely administered, and, in as in other pains associated with rheumatism, are of great benefit. Atropin, of course, is of the greatest value. The dietetic and hygienic measures employed with rheumatic affections in general should be promptly instituted.

The infectious fevers—septicemia, pyemia, malaria, typhoid fever, influenza, etc.—are occasionally attended by parenchymatous iritis and hypopyon due to infection of the iris by their respective bacteria through the blood stream (endogenous infection).

Perhaps one of the most common causes of parenchymatous iritis is *local infection* of the iris. This may occur in the course of unclean surgical operations upon the eye, or it may be due to traumatism or the entrance of foreign bodies into the eyeball. It may also arise secondarily from perforation of a corneal ulcer.

Very rarely it may be impossible to attribute the affection to any cause.

Symptoms.—The principal symptoms and those of diagnostic importance are the swelling of the iris with the formation of nodules and the purulent exudate in the anterior chamber. The changes in the size, shape, and motility of the pupil are also of importance. The course varies according to the underlying cause.

Treatment.—In syphilitic cases the free use of mercury and the iodids hastens the absorption of the nodules. In this variety, as in tubercular iritis, tonics and stimulants should be employed to combat the attendant anemia. Those cases due to diabetes require the usual dietetic and medicinal measures indicated in

that disease. Infected cases may be prevented to a great degree by extreme asepsis during operations and by avoiding operation in cases associated with lacrymal or other adjacent purulent affections. Locally, atropin should be instilled in order to prevent adhesions and to place the ciliary body at rest. Frequent irrigation is necessary in infected cases.

Diagnosis.—Iritis may be confused with simple conjunctivitis, phlyctenular conjunctivitis, keratitis, and acute glaucoma. In differentiating these affections it is of the utmost importance to consider in detail the condition of every portion of the eye. The presence of superficial or deep congestion of the conjunctiva, the transparency and sensation of the cornea, the depth of the anterior chamber, the color of the iris, the reaction of the pupil to light accommodation and convergence, the condition of the media and fundus, and the tension should receive the most careful attention. In iritis, for instance, the conjunctiva is normal; there is a fine deep pericorneal injection forming an immovable pink zone around the cornea; triangular punctate deposit upon the lower half of the posterior layer of the cornea in some cases, but usually the cornea retains its normal condition in simple cases; normal depth of the anterior chamber unless accompanied by complications; hypopyon in purulent iritis; the iris is always discolored, as may be ascertained by comparison with its fellow; the pupil is small and reacts to light very sluggishly, if at all, and upon the instillation of a mydriatic becomes markedly irregular, showing the presence of adhesions; the eyeground and media are unaltered in uncomplicated cases; and the tension is normal in most cases. In addition there will be neuralgic pain, worse at night, tenderness over the ciliary region, and gradual diminution in vision, but no contraction of the visual field.

In *simple conjunctivitis* the inflammation is limited to the conjunctiva, the vessels of that structure are enormously engorged, but pericorneal injection, Descemetitis, hypopyon, discoloration of the iris, changes in the size and motility of the pupil, synechiæ, and neuralgia are absent. There is considerable mucopurulent discharge in conjunctivitis, and none at all in iritis.

In *phlyctenular conjunctivitis* the occurrence of the phlyctenules upon the cornea may give rise to pericorneal injection in addition to its other characteristic symptoms, but a careful ex-

TABLE OF DIFFERENTIAL DIAGNOSIS

	Iritis.	Acute Inflammatory Glaucoma.	Simple Conjunctivitis.
Pain.	Brow pain worse at night.	Intense headache and radiating pain in eyeball. Pain may be so severe as to cause nausea and vomiting.	Irritation of eyelids and conjunctiva. Sandy or gritty feeling. No pronounced pain.
Vision.	Dim.	From dimness to blindness.	Unaffected after eyeball is cleared of secretion.
Pupil.	Contracted. Sluggish or immobile.	Green reflex. Dilated; sometimes *ad maximum*.	Unaffected.
Vascular Injection.	Fine, deep, pericorneal injection; immovable.	Dark red conjunctival injection. Vessels dilated.	Diffuse conjunctival engorgement; movable and superficial.
Cornea.	In some cases triangular, punctate deposits on lower half of posterior surface, the apex of the triangle directed upward.	Sensitiveness diminished to complete anesthesia. (Slight haziness to dullness (steamy).	Unaffected.
Anterior Chamber.	Normal in uncomplicated cases. Deeper with complete annular synechiæ. Aqueous humor may be turbid.	Shallow.	Unaffected.
Refraction.	There may be transient myopia or astigmatism.	Generally hypermetropia during prodromal stage, lessened power of accommodation.	Not influenced by conjunctivitis, although the latter may be a symptom of ametropia.
Tension.	Generally normal. Tenderness on pressure.	Increased from slight to stony hardness.	Unaffected.
Iris.	Discolored. Surface may be irregular.	Appears discolored. Due to pressure on epithelium of the cornea.	Unaffected.
Age.	Common before forty.	Rare before forty.	May occur at any age.
Causes.	Syphilis; rheumatism; gonorrhea; diabetes; gout; infectious diseases; tuberculosis; trauma.	Race; Jews predisposed; arteriosclerosis; emotional disturbances; trauma; intra-ocular growths; closure of iris triangle.	Ametropia; trauma; infection; constitutional diseases; drugs; exanthemata.
Fundus.	Usually obscured.	Cupping of disc.	Unaffected.

[illegible] to detect any alterations in the iris and pupil, [illegible] under iritis.

[illegible] characterized essentially by diffuse or localized [illegible] unattended by ciliary tenderness, nocturnal neu[illegible] changes in the iris or pupil unless complicated by iritis. [illegible] the pain is severe, but not necessarily nocturnal; [illegible] vessels are dark-red in color and widely dilated; [illegible] is hazy and less sensitive than normal; the iris is dis[illegible] the pupil is dilated and sluggish and filled by a green [illegible] the tension is enormously increased; the anterior chamber [illegible] and the iris is in close contact with the cornea; there [illegible] diminution of vision with contraction of the visual field, [illegible] marked toward the nasal side; and the characteristic cup[illegible] of the optic nerve. Atropin should never be instilled in these cases, as it serves to aggravate the condition.

Although these affections usually exist alone, they may be encountered combined and should be recognized promptly, as the treatment is materially altered in such cases. The occurrence of glaucoma in the course of iritis, for instance, often requires operative measures.

The distinction between the several varieties of iritis is not as important as at first glance would seem to indicate. However, if the occasion arises for such a differentiation, it may be made by remembering that adhesions of the iris to the lens are most marked in plastic iritis; that punctate keratitis is almost entirely limited to serous iritis; and that hypopyon and nodular formations in the iris are characteristic of parenchymatous iritis.

Treatment in All Forms of Iritis.—Owing to the difficulty in distinguishing the various forms of iritis and the danger of delay in waiting for the characteristic symptoms of each to develop, it is necessary to employ a mode of treatment applicable to all. A saline purgative should be administered at once to bring about depletion. Owing to the prominence of syphilis as an etiologic factor, mercury should be administered until its physiologic limit is reached. The preparation of the drug is of minor importance, my own preference being for mercury and chalk, 1 (.06) to 5 (.3) grains three times daily, and inunctions of mercurial ointment. There are some patients possessing such peculiarities of constitution that they cannot bear the administration of mercury

PLATE III

1

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1.—Schematic drawing showing the differential diagnosis between iritis (left) and conjunctivitis (right). On the left is shown the fine pink pericorneal injection, the discolored, spongy iris, and the irregular, bound-down and contracted pupil of iritis. On the right the coarse red conjunctival injection, regular pupil, and normal iris of catarrhal conjunctivitis.

2.—Fascicular keratitis. (Author's case.)

3.—Mycotic ulcer of cornea due to aspergillus fumigatus. (Author's case.)

4.—Leucosarcoma of the iris. (Author's case.)

even in small doses. It would be excessively injurious to continue this treatment. In such cases, however, I have found the following prescription a remedy capable of arresting inflammations of the iris, even where it may be combined with severe supra-orbital pains and other acute symptoms. This remedy (oleum trebinthinæ rectificatum) found great favor among the English ophthalmic surgeons:

℞ Olei terebinthinæ rectificati (Merck's)	℥ijß;	80.0
Pulv. acaciæ	ʒvj;	24.0
Vitellus ovi	no. ij;	
Elixir aromatici ....fl	℥j;	30.0
Sodii bicarbonatis	gr. xxvij;	1.8
Aquæ cinnamomi........q. s. fl	℥viij;	240.0

Misce. Sig.: Teaspoonful in water three times daily after meals.

The salicylate of strontium (5 (0.3) to 10 (0.6) grains three times daily), the wine of colchicum (10 drops (0.6) every three hours until free purgation), aspirin, potassium iodid, quinin, and salicylate of sodium may be administered in addition, particularly if there is any reason to suspect rheumatism as an underlying cause. Diabetes is in very rare cases a cause of iritis and should always be considered. In severe cases it will be necessary to place the patient at absolute rest in bed in a darkened room. The diet should not include nitrogenous foods or alcoholic stimulants. Free purgation by means of saline cathartics and diaphoresis by hot baths and the hypodermatic injection of pilocarpin ($\frac{1}{4}$ grain (0.015)) are indicated every second day for one week, provided there is no cardiac contraindication.

Locally, mydriatics, such as atropin, duboisin, daturin, etc., should be instilled every three hours until the pupil is widely dilated. In cases of chronic iritis it is often of great value, as practiced by Coover and Marbourg, to apply locally gr. $\frac{1}{10}$ (0.006) of equal parts of powdered atropin and dionin, the eye having been previously cocainized. Instead of simply applying a piece of cotton to the inner canthus, the author uses the canaliculus clamps already described, and after sufficient time has elapsed

for the action of the drugs (3 minutes) the eye is irrigated and the patient's head turned so that the irrigating fluid will wash off any excess of the drugs. Adrenalin should be employed in combination with this mydriatic, and if conjunctivitis is present silver nitrate, 5 grains (0.3) to the ounce (30.0), may be applied. Subconjunctival salt injections should also be used. The application of leeches to the temple and *venesection* aid materially in lessening the severity of an attack. Hot fomentations of poppy heads, applied over the circumorbital region, serve to relieve the pain to a considerable degree. In cases in which the iris is bound down to the lens capsule and ordinary medical treatment does not seem to modify the inflammation, an iridectomy, even when the disease is at its height, is advisable, and should be performed. The author has carried out this line of treatment in many serious cases with excellent results. The operation is performed in the usual manner, the iris being separated from the capsule with a Streatfeild ivory spatula or the author's corelysis hook. Sleep must be induced and the pain lessened by hypodermatic injections of morphin.

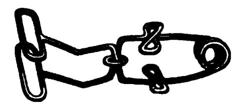

FIG. 91.—CANALICULUS CLAMP.

For closing canaliculi to prevent entrance of drugs into lacrymo-nasal passages.

In traumatic iritis the iris should be carefully replaced if prolapsed, in addition to the other measures recommended. If the prolapse is large, excision may be required.

Prognosis and Sequelæ.—An attack of mild iritis soon attains its height in a few days, runs an even course for ten days, and imperceptibly disappears at the end of three or four weeks. In the more severe forms the disease may be prolonged and extend over a number of months. A large percentage of cases when subjected to prompt treatment terminate favorably, leaving no traces of the former inflammation. Recurrences are frequent when synechiæ are left behind. In all forms of iritis there is coincident congestion of the ciliary body, but in the severe varieties actual cyclitis occurs, and is manifested by violent inflammatory symptoms, tenderness in the ciliary region, Descemetitis, etc. The entire uveal tract is also the seat of inflammation in some cases.

Among the sequelæ may be mentioned anterior and posterior

synechiæ, occlusion of the pupil, atrophy of the iris, deposits upon the anterior capsule of the lens, cataract, and vitreous opacities. In annular posterior synechia the pupillary margin is bound down by adhesions throughout its entire extent, giving rise to a condition known as *exclusion of the pupil.* If the lymph thrown into the pupillary space becomes organized, *occlusion of the pupil* re-

FIG. 92.—SECTION OF THE ANTERIOR PORTION OF THE EYEBALL SHOWING THE IRIS IN ITS NORMAL RELATIONS. (After Dr. Chas. H. May.)

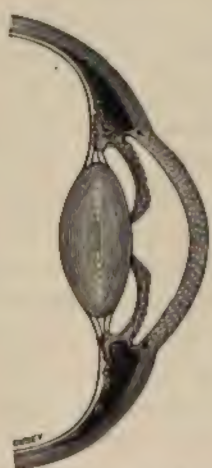

FIG. 93.—SECTION SHOWING ANNULAR POSTERIOR SYNECHIA (EXCLUSION OF THE PUPIL). (After Dr. Chas. H. May.)

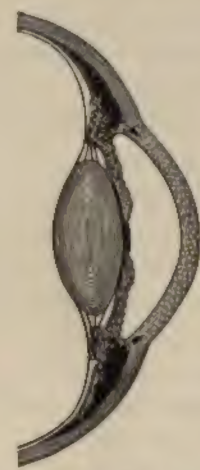

FIG. 94.—SECTION SHOWING TOTAL POSTERIOR SYNECHIA AND OCCLUSION OF THE PUPIL. (After Dr. Chas. H. May.)

sults. The tension posterior to the iris causes it to bulge forward, producing the condition known as *iris bombé.* Secondary glaucoma is liable to follow this condition, and unless relieved blindness will result.

ATROPHY OF THE IRIS

Atrophy of a sector of the iris is an extremely rare condition, and consists in the entire absorption of the stroma and pigment, leaving behind nothing but the meshwork of the radiating and circular fibers. These thin fibers may be easily seen by the aid of the ophthalmoscope. In a case under my charge at the Medico-Chirurgical Hospital a quadrant of the iris was thus af-

fected. The sector gradually changed from year to year, and the condition was evidently of neuroparalytic origin, as no history could be obtained as to its probable cause.

Atrophy of the iris also occurs as a sequel of inflammation of the iris.

TUMORS OF THE IRIS

The lesions of syphilis and tuberculosis are probably most common morbid growths in the iris, but their descriptions are included under *parenchymatous iritis.*

Cysts occasionally form in the iris, and nearly always result from some form of traumatism to the iris. Their contents may be serous in character or semisolid, due to the transplantation of epidermoid elements, such as an eyelash or a portion of the epidermis of the lid. They vary in size from very minute bodies to enormous enlargements that may fill the entire anterior chamber and induce glaucoma, irido-choroiditis, or sympathetic ophthalmia by pressure. Cysts of the iris may be single or multiple, unilateral or bilateral. They are not malignant and are dangerous only by the pressure they occasion. Removal through a corneoscleral wound is always indicated, and any adherent iris should also be removed by excision.

Granulomata sometimes occur in the iris and present the appearance of ordinary granulation tissue. Such growths are benign and of a pale color. They enlarge gradually and eventually lead to rupture of the globe anteriorly with the production of phthisis bulbi. They are believed to be of syphilitic or tubercular origin. They should not be confused with the granulomatous condition of the iris that sometimes follows its prolapse. They often extend to the angle of the anterior chamber (Parsons). Excision of the growth is recommended.

Melanoma is a rather frequent condition and consists in an hypertrophy of hyperpigmented areas of the iris, and while usually benign and of no significance, it may be a precursor of sarcoma.

Sarcoma of the iris is a rare affection. Its occurrence as a primary growth is extremely rare. Knapp, Fuchs, Treacher Collins, Veasey, C. A. Wood, and Brown Pusey have brought the literature of the subject to date. It may take place in the iris at first

or it may involve the iris and ciliary body. The growth is pigmented in most cases and enlarges very gradually in the early stages, but later it increases rapidly in size, being attended by pain, hemorrhage, etc. Eventually the globe is ruptured and a fungus-like mass protrudes. Metastasis soon takes place and death is a certain result. Removal of the growth when very small is indicated, but later enucleation of the eyeball will be necessary. The prognosis is always unfavorable. Secondary growths are usually found at a later period in the liver. Leucosarcoma of the iris has been described by Alt, Limbourg, etc., but it is more rare than the melanotic form. (See Plate III.) It retains the malignant character common to all sarcomata. A patient with a leucosarcoma of the iris was referred to the author by Dr. Pollard, of Atlantic City. Seventy applications of the X-ray were made. The treatment seemed to retard the growth —in fact, it became smaller and has since remained *in statu quo* for over a year.

Nævi occasionally present themselves in the iris owing to the vascular structure of that membrane. According to Fuchs, pigmented nævi usually are situated in the anterior limiting layer of the iris. Operative interference is contraindicated unless vision is greatly obstructed.

Leprosy may be attended by the deposition of the characteristic nodules in the iris. This is always rare, but is mostly observed in connection with leprosy of the face, in which the natural folds of the skin are markedly exaggerated and the face assumes the characteristic lionlike expression.

Ophthalmia nodosa may affect the iris and conjunctiva, in which small hard nodules are found in those structures. It is extremely rare and is caused by the contact with an irritating substance contained within the hairs of certain kinds of caterpillars. These hairs may be demonstrated in the nodules upon excision. (See Conjunctivitis Nodosa.)

All growths of the iris tend to involve the ciliary body, and even the most benign are liable to be attended by dangerous symptoms from the pressure they occasion. The intra-ocular tension is always increased, and glaucoma, iridocyclitis, and sympathetic ophthalmia are possible terminations in the most favorable cases.

INJURIES OF THE IRIS

Traumatism applied to the globe of the eye may result in nonperforating or perforating wounds of the iris.

Nonperforating wounds are always due to concussion, such as that induced by a blow upon the eye. They include traumatic mydriasis, rupture of the iris at its pupillary margin, and iridodialysis or separation of the iris from its ciliary attachment.

Traumatic Mydriasis consists in permanent dilatation of the pupil, and results from paralysis of the sphincter at the pupillary margin. Eserin should be instilled in this condition.

Rupture of the Iris includes tearing of the pupillary margin and complete rupture of the sphincter of the iris. Mydriasis is present. In small lacerations it may be very difficult to detect the gaping. Atropin should first be instilled and followed later with eserin.

Iridodialysis, or rupture of the iris at its ciliary attachment, is characterized by the formation of an artificial pupil at the periphery through which the red reflex of the fundus shines. This is usually small and the artificial aperture is semilunar in shape, but in very rare instances the iris may be separated entirely from its ciliary attachment and be found lying in the bottom of the anterior chamber or under the conjunctiva after having escaped through a rent at the corneoscleral margin. Complete detachment of the iris due to injury constitutes *traumatic aniridia*.

FIG. 95.—IRIDODIALYSIS, FOLLOWING TRAUMATISM FROM A SPENT RIFLE BALL. (Author's case.)

Iridodialysis is always accompanied by more or less hemorrhage into the anterior chamber, photophobia, and pain. The condition is usually incurable. A detached iris is always liable to displacement, and this occurs in two forms: *retroflexion*, in which the iris is folded back upon the ciliary processes, and *anteflexion*, in

which it is twisted forward upon itself so as to expose to view its uveal surface. Complete displacement constitutes the condition already described as traumatic aniridia.

The treatment consists in the prolonged use of atropin, but unless the detachment is extremely small the likelihood of restoration to normal is not great.

Perforating wounds of the iris include incised or penetrating wounds with or without the entrance and retention of foreign bodies. Perforating wounds seldom involve the iris alone, but injure the ciliary body and lens to a greater or less extent. An incised wound of the iris alone is not a serious condition and is repaired promptly. A frequent condition after perforating wounds of the anterior segment of the eye is prolapse or hernia through the cornea or sclera. In such cases efforts should be made to carefully replace the prolapsed portion, but if these are unsuccessful, excision is indicated. Strict antiseptic precautions should be observed in all these injuries. As already stated, wounds of the iris nearly always involve the cilary body, or lens, or both. In the case of the ciliary body, inflammation or cyclitis is frequent, and the possibility of sympathetic ophthalmia should always be borne in mind. Involvement of the lens is always followed by an opacity of varying size, sometimes extending throughout the entire structure, constituting traumatic cataract.

The treatment in these cases consists first in placing the eye at rest by the instillation of atropin and cleansing it by frequent irrigation with warm boric-acid solution, and later in meeting the symptoms as they arise. Discission will be required for traumatic cataract, and enucleation will be indicated if sympathetic disease supervenes.

Perforating wounds of the iris induced by the entrance of foreign bodies deserves special consideration. There is always an additional element of danger from infection, particularly if the foreign body is retained.

FOREIGN BODIES

Foreign bodies may sometimes become encysted in the parenchyma of the iris without exciting an irritation for a long time. Several years ago the author assisted Dr. Bickerton, of Liverpool, in the removal of a piece of glass from the anterior chamber

of an eye. The glass had been driven through the cornea, the result of an explosion. The foreign body did not cause any irritation of the iris for a number of years. Recently a patient was seen at the Medico-Chirurgical Hospital with a small piece of slag in the anterior chamber (2 × 3 mm.), the result of an explosion. This foreign body which irritated the iris caused great pain and iritis. A horizontal incision was made in the cornea just above the foreign body, the upper lip of the wound pressed backward, and with an iris forceps the bit of slag removed. The eye recovered with a perfectly round pupil.

Another interesting case occurred in the practice of the author in which a small piece of steel had been driven into the iris and was followed by no reaction. The foreign body became encysted, and several years afterwards the patient presented himself for treatment, complaining of pain and dreading the occurrence of blindness. Examination at this time showed slight ciliary congestion. The color of the affected iris was changed to a rusty gray, while the fellow iris retained its original light-gray color. By means of a corneal microscope the foreign body was located by a slight elevation in the peripheral margin of the iris. It was subsequently removed by an iridectomy and relief of the symptoms followed. The microscopic examination of the excised portion revealed the presence of a partially oxidized piece of steel. In such cases it may become necessary to resort to the Haab magnet.

Treatment.—In all wounds of the eye cocain should first be instilled in order to render subsequent examination and treatment painless. The eyeball and conjunctiva should then be irrigated by means of a warm boric-acid or weak bichlorid-of-mercury solution (1–10,000). The presence of foreign bodies in the anterior chamber and iris are usually easily detected, and if metallic, should be extracted through the wound of entrance by means of the magnet. If the foreign body is nonmetallic, it may be removed by enlarging the original wound in the cornea and extracting it by means of a small pair of forceps. It must be remembered that an escape of blood into the anterior chamber follows nearly every wound of the iris and renders every examination difficult, so that operative interference should always be postponed until absorption takes place, which is usually a matter of

but twenty-four or forty-eight hours. In all cases atropin should be frequently instilled and cold applications should be constantly made to combat inflammatory reaction.

OPERATIONS UPON THE IRIS

Iridotomy [1] consists in simply dividing the iris at a certain plane, and is most frequently employed for the production of an artificial pupil. Owing to the danger of wounding the lens in incision of the iris, the operation should be reserved for cases in which there is aphakia. The eye should be prepared and cocainized in the usual manner. A broad needle is then thrust through the cornea and iris 2 lines from the corneoscleral margin, in a direction perpendicular to that of greatest tension. A De Wecker scissors is then introduced into the corneal incision, one blade passed into the anterior chamber and in front of the iris, while the second blade is passed into the vitreous, after which a horizontal cut is made by the scissors. Sometimes a V-shaped incision is made which allows contraction of the iris, and a larger pupil results. The operation through the sclera with an Adams knife is not followed by modern-day ophthalmic surgeons.

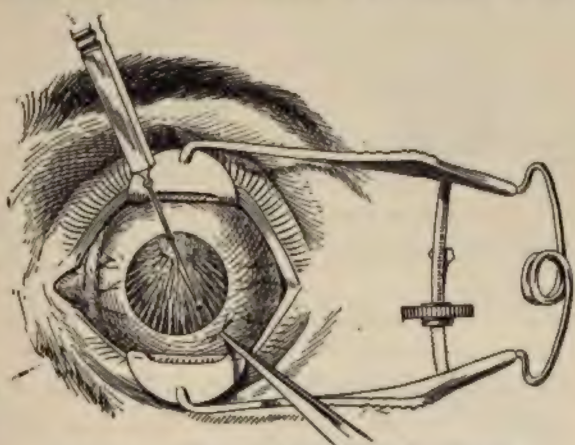

FIG. 96.—ZIEGLER'S V-SHAPED IRIDOTOMY.

ZIEGLER'S V-SHAPED IRIDOTOMY.—As described by the author himself, the operation is performed as follows with his modified Hays knife-needle:

First Stage.—With the blade turned on the flat, the knife needle is entered at the corneoscleral junction, or through the upper part of the cornea (Fig. 96), and passed completely across

[1] Cheselden performed the first operation for artificial pupil in 1728. *Philosophical Transactions*, vol. xxxv.

the anterior chamber to within 3 mm. of the apparent iris periphery. The knife is then turned edge downward and carried 3 mm. to the left of the vertical plane (Fig. 97).

Second Stage.—The point is now allowed to rest on the iris membrane, and with a dartlike thrust the membrane is pierced. Then without making pressure on the tissue to be cut, the knife is drawn gently up and down with a sawlike motion, until the incision has been carried through the iris tissue from the point of the membrane puncture to just beneath the point of the corneal puncture. This movement is made wholly in a line with the axis of the knife, the shank passing to and fro through the corneal puncture, and the loss of any aqueous being carefully avoided in the manipulation.

Third Stage.—The pressure of the vitreous will now cause the edges of the incision to immediately bulge open into a long

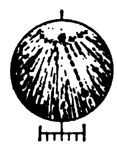

FIG. 97.—PLAN OF FIRST INCISION.

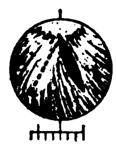

FIG. 98.—FIRST INCISION COMPLETED.

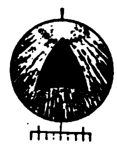

FIG. 99.—PUPIL RESULTING FROM V-SHAPED IRIDOTOMY.

oval through which the knife blade is raised upward, until above the iris membrane, and then swung across the anterior chamber to a corresponding point on the right of the vertical plane, which, owing to the disturbance in the relation of the parts made by the first cut, is now somewhat displaced and the second puncture must be made at least 1 mm. farther over—i. e., 4 mm. to the right of the vertical plane (Fig. 98).

Fourth Stage.—With the knife point again resting on the membrane; a second puncture is made by the same quick thrust, and the incision rapidly carried forward by the sawing movement to meet the extremity of the first incision, at the apex of the triangle, thus making a *converging* V-shaped cut. Care must be taken at this point that the pressure of the knife edge on the tissue shall be most gentle, and that the second incision shall terminate a trifle inside the extremity of the first, in order that the last fiber may be severed and thus allow the apex of the

flap to fall down behind the lower part of the iris membrane. If the flap does not roll back of its own accord it may be pushed downward with the point of the knife. When the operation is completed the knife is again turned on the flat and quickly withdrawn.

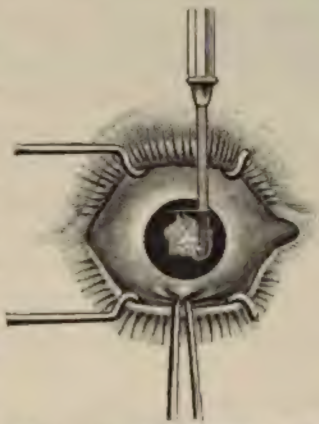

FIG. 100.—STREATFEILD'S OPERATION FOR POSTERIOR SYNECHIÆ.

Iridectomy, or excision of a portion of the iris, is indicated in glaucoma, in the combined operation for cataract extraction, in the formation of an artificial pupil, and in chronic iritis. The operations in glaucoma and cataract differ considerably, and are described in detail in the chapters on Glaucoma and Diseases of the Crystalline Lens (*q. v.*).

Iridectomy for the formation of an artificial pupil should always be performed directly back of a clear portion of the cornea.

FIG. 101.—AUTHOR'S CORELYSIS HOOK.

The keratome should be inserted about 1 mm. behind the cornea, just where the scleral tissue seems to overlap it, and the incision is made long enough to afford sufficient room for withdrawing the iris, which is then cut off with one snip of De Wecker's scissors. Sometimes posterior synechiæ are present, and these should be first released by a Streatfeild ivory hook before withdrawing the iris, or with the author's corelysis hook (Fig. 101).

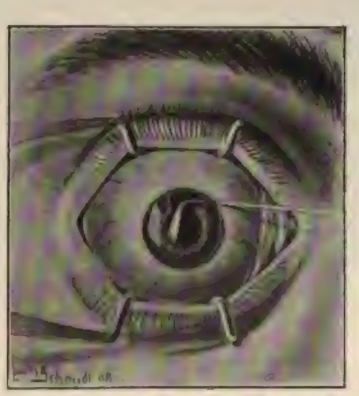

FIG. 102.—CORELYSIS OPERATION FOR POSTERIOR SYNECHIA, SHOWING CORELYSIS HOOK IN SITU.

In chronic iritis the operation is practically the same as that for the formation of an artificial pupil, with the exception that it is more difficult on account of the dense adhesions of the iris to the lens capsule. Tyrrell's hook should be used to release these adhesions, but occasionally the forceps will be necessary. Is is impossible to avoid tearing some irides. In such cases, after a portion of the iris has been removed, the author's corelysis spatula may be used to complete the loosening of the synechiæ. The iris may remain stationary even after released from the lens if atrophy of its fibers has occurred.

The reëstablishment of the communication between the chamber of the vitreous and that of the aqueous may prevent a recurrence of iritis when all other treatment has failed.

DISEASES OF THE CILIARY BODY

INFLAMMATION

Cyclitis.—Inflammation of the ciliary body usually occurs in combination with iritis or inflammation of the entire uveal tract. Occasionally it is observed as a separate and distinct affection. The term iridocyclitis is applied when, in addition to pronounced symptoms of iritis, there are neuralgia and tenderness in the ciliary region, most marked during efforts at accommodation, deposits upon Descemet's membrane, increased tension, and vitreous opacities. It is an extremely serious affection, and not only impairs vision, but may lead to destruction of the eyeball.

Primary cyclitis may be idiopathic in origin, but is most commonly due to ocular traumatism.

Owing to the close relation cyclitis bears to iritis, it may be divided into three principal varieties corresponding to those of iritis: plastic, serous, and purulent.

Plastic cyclitis may be acute or subacute, and is characterized by severe pain, marked ciliary tenderness, decided pericorneal injection, often of a purplish color, deep anterior chamber, retraction of the base of the iris with dilatation of the pupil, and usually diminution in the intra-ocular tension.

The disease shows a marked tendency to extend to other portions of the uveal tract, and in such cases the condition is termed *plastic uveitis.* The resulting exudation permeates the anterior

chamber, pupil, iris, ciliary body, vitreous, etc., and upon its subsequent contraction results in detachment of the retina, blindness, and atrophy of the globe. Degenerated and shrunken eyeballs following plastic iridocyclitis may remain quiescent for a comparatively long period, but a recurrence of the affection is always a possibility, and in such cases sympathetic ophthalmia in the other eye is always to be feared.

The cause of plastic cyclitis is usually injury to the ciliary body, such as occurs in penetrating wounds and cataract operations. Syphilis and tuberculosis are also etiological factors.

The treatment is the same as that recommended in plastic iritis. In the early stages the response to treatment is often prompt and the vision is retained in part, but in the greater number of cases the eyeball becomes useless as a visual organ.

Serous Cyclitis (*Uveitis; Descemetitis; Aquo-capsulitis; Keratitis punctata; Serous iritis*).—Serous cyclitis is a chronic affection and is intimately associated with serous iritis. It is most common in young adults, and shows a marked tendency to recur. It is unilateral at first, but often attacks the remaining eye at a later period.

FIG. 103.—KERATITIS PUNCTATA OR DESCEMETITIS.

It is characterized by a serous exudation which manifests itself chiefly as deposits of various sizes on the membrane of Descemet and on the capsule of the lens. These deposits take the form of opaque dots on the posterior layer of the cornea and are arranged in the shape of a triangle with its apex pointing upward, constituting the condition known as *keratitis punctata*. There is slight pericorneal injection and the cornea and aqueous humor are

somewhat hazy. The anterior chamber is deeper than normal and the pupil is semidilated and immobile. In the early stages the intra-ocular tension is likely to be high, but approaches normal as the case progresses. There is very little supra-orbital pain and slight tendency toward the formation of adhesions. The tension may be increased at first, and later reduced.

Etiology.—The affection is probably most often encountered in association with other ocular inflammations, particularly the early stages of sympathetic ophthalmia. It also occurs as a manifestation of some constitutional affection, such as syphilis, gout, rheumatism, anemia, etc., and in these cases is bilateral. It is observed with great frequency in women with uterine affections.

Symptoms.—The disease is characterized by deepening of the anterior chamber, turbidity of the aqueous, dilatation of the pupil, vitreous opacities, increased tension, and marked impairment of vision, all of which vary widely in their intensity. The diagnostic feature, however, is the punctate deposits upon the membrane of Descemet. The course of the affection is extremely chronic and there are no signs of active inflammation. The affection is often prolonged by involvement of other portions of the uveal tract, a not uncommon occurrence.

Conditions such as choroiditis, scleritis, and glaucoma are likely to supervene in the course of serous cyclitis, and complicate it considerably.

The treatment is also similar to that of serous iritis (*q. v.*), but it must be remembered that in some cases, particularly those in which the tension is greatly increased, eserin or pilocarpin must be substituted for atropin.

Treatment.—Usually the depressed state of the patient calls for free administration of tonics, such as alcohol, strychnin, iron, quinin, etc., and an extremely nourishing diet. Mercury, although indicated on account of the presence of some syphilitic taint, should be withheld temporarily in many cases on account of its depressing effect. Free purgation, diaphoresis, and diuresis are to be employed routinely. The internal administration of iodid of potassium or iodid of iron will aid in the absorption of the inflammatory products. Locally, atropin should be instilled, but not so frequently as in plastic iritis. An increase of tension

indicates paracentesis of the cornea, but if this procedure fails to relieve it, resort to an iridectomy may be necessary.

Purulent cyclitis always consists of a purulent iridocyclitis. It may be noninfective, in which case there is hypopyon in addition to the symptoms of acute iritis and cyclitis combined. The septic variety is most frequent and follows infective ulcer of the cornea, and septic wounds following traumatism and operations. It may also be induced by septic emboli in the course of pyemia, septicemia, meningitis, and cerebrospinal meningitis.

Symptoms.—In the severe cases there is present marked pericorneal injection, swelling of the lids, congestion, and chemosis of the conjunctiva, pus in the aqueous and vitreous, increased tension, and severe ciliary neuralgia.

The treatment is that of purulent iritis. Panophthalmitis, blindness, and shrinking of the globe are common terminations.

TUMORS OF THE CILIARY BODY

Sarcoma of the ciliary body may occur in two forms: the small round cell and the myxosarcoma. It makes its appearance first as a brownish mass posterior to the iris and induces glaucomatous symptoms. As it enlarges it produces symptoms common to other ocular sarcomata., *Gumma*, primary and metastatic *carcinoma, adenoma, myoma, glioma,* endothelioma, and epithelial hyperplasias of the ciliary body have been reported.

The *treatment* consists in enucleating the eyeball as soon as a growth is discovered with the exception of the gumma, which under prompt antisyphilitic treatment rapidly absorbs.

INJURIES OF THE CILIARY BODY

Injury to the ciliary body is always a serious condition, owing to the frequency with which plastic iridocyclitis is thereby produced and the possibility of sympathetic ophthalmia in such cases. An area of 5 mm. in width surrounding the cornea represents the location of the ciliary body, and is termed the "danger zone," as wounds in this region are almost certain to implicate the ciliary body. The direction from which a foreign body or pen-

knife enters the "danger zone" should always be most carefully noted. The sclera alone may be wounded, and the ciliary body escape; in such cases the wound is not serious. Care should always be taken to note this distinction on account of the difference in the prognosis.

Treatment.—In the absence of prolapse of the ciliary body or iris or of a foreign body thorough cleansing, together with the instillation of atropin and the application of cold compresses, will suffice unless complications occur.

Prolapse of the iris or ciliary body requires abscission of the prolapsed portion, and the solid stick (silver nitrate) applied to the wound to insure rapid healing. Wounds of the sclerotic that are not infected may be sutured if no foreign body is present.

The prognosis should always be guarded. Sympathetic ophthalmia is likely to occur in most cases, but occasionally the eye is restored almost to its normal condition. (See Sympathetic Ophthalmia.)

CHAPTER X

DISEASES OF THE CHOROID

GENERAL CONSIDERATIONS

THE situation of the choroid between the retina and sclera, and its continuation into the ciliary processes and iris, often cause it to be diseased as a result of morbid processes in those structures. It is made up largely of blood-vessels and pigment cells

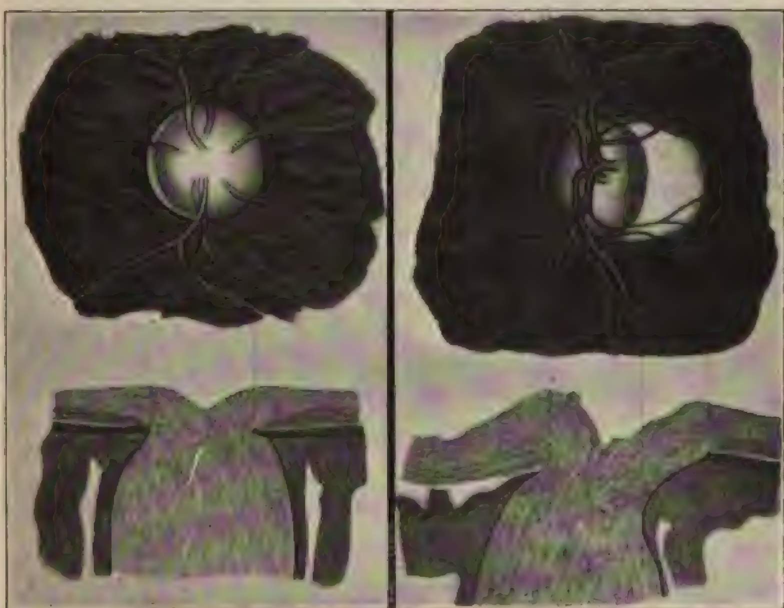

FIG. 104.—NORMAL FUNDUS. LARGE SEMILUNAR CONUS.

supported by delicate connective tissue, and it is these elements that are altered by pathological affections of the choroid. Its function is that of nutrition, and any inflammatory or other condition interfering with this function results in serious damage to the retina, vitreous, or lens.

Diseases of the choroid seldom give rise to external manifestations, but are detected by the ophthalmoscopic appearances they present. After the subsidence of the diseased condition and its exudate has been absorbed, traces of the disease remain in the shape of highly pigmented patches with a general diminution in the color of the fundus and white atrophic areas.

It is important to distinguish these appearances from the variations in the choroid in perfect health. The pigment may be large or small in amount, normally depending upon the complexion of the individual, and when in excess is most marked in the macular region. In the dark races the fundus has a uniformly slate-colored appearance, while in fair persons and young children the vessels are darker in color than the pigment interspaces. In dark persons the color of the interspaces is deeper than that of the vessels, and they appear as islands of pigment (tesselated fundus). In old age there is a physiological decrease in the pigment epithelium. The blood-vessels of the choroid are distinguished from those of the retina by the absence of the light streak along their centers. Hemorrhage in the choroid may be differentiated at times by the rounded outline and the superimposed retinal striation, but usually the exact location of fundus hemorrhages escapes detection.

CONGENITAL ANOMALIES

Albinism.—Albinism is characterized by an absence of pigment from the uveal tract, and is accompanied by yellowish-white hair, eyebrows, and eyelashes, and the absence of pigment from the skin. The iris is generally of a pink or lavender color, and the pupil may show a red reflex even by ordinary illumination. In the most pronounced cases strong light is unendurable to the patient. The defect is probably hereditary, and in many cases is attended with very marked errors of refraction, especially astigmatism and hyperopia; nystagmus and strabismus are common. The eyes are usually partly closed so as to lessen the amount of light entering them, and to diminish the effects of imperfect focusing. The blood-vessels of the choroid and retina are seen with vivid clearness.

Coloboma of the Choroid.—Two forms of this congenital anomaly have been observed.[1]

In the more common form there is a deficiency of the choroid extending backward from the ciliary region toward the optic

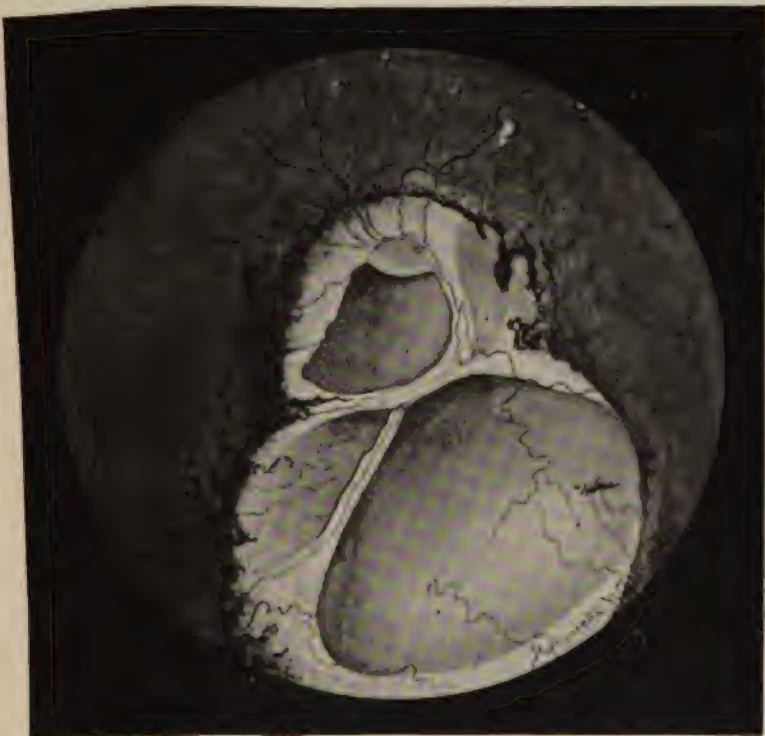

FIG. 105.—COLOBOMA OF CHOROID AND OPTIC NERVE. (Author's case.)

disk; this form is frequently associated with coloboma of the iris. The other variety consists of a more or less circular defect of the choroid, which may be located at the macula or in other parts of the fundus.

In the first form the gap is frequently crossed by retinal vessels, and occasionally by choroidal vessels. The margins of the coloboma are generally pigmented, being of a brownish hue. This condition is distinguished from choroidal atrophy and opaque nerve fibers chiefly by its symmetrical pyramidal form and by the pigmentation of its margin.

[1] See Choroidal Fissures in chapter on Development of the Eye.

HYPEREMIA OF THE CHOROID

A condition of congestion of the choroid which precedes all inflammatory affections of that structure, and also accompanies eye-strain, exposure to heat and light, and the instillation of cocain, homatropin, adrenalin, etc. This condition is extremely difficult to detect, and is seldom recognized. It is often confused with exposure of the choroidal vessels subsequent to absorption of the pigment epithelium.

Symptoms.—There are no subjective manifestations. Viewed through an ophthalmoscope the fundus presents a "woolly" appearance and lacks the normal uniform red color. The nerve head is distinctly red and is surrounded by striations of the retina.

Treatment.—The examination of the refraction should be performed under mydriasis in these cases, and usually relief will be brought about by the constant wearing of the correcting lenses. When the hyperemia passes over into true inflammation more active measures should be employed. Bromid of potassium and ergot have been recommended.

CHOROIDITIS

A condition characterized primarily by hyperemia and later by exudation and hemorrhages into the choroid. As the exudate is absorbed the diseased areas are replaced by connective tissue and appear as white atrophic spots. It may be associated with diseases of the sclera, iris, or retina, or it may exist independently. In most cases **subjective symptoms** are absent. A diminution in the visual acuity commonly results proportionate to the destruction of the eye ground. The diagnosis is made by means of the ophthalmoscope, and depends upon the alterations in color of the fundus, due to changes in the pigment epithelium and blood-vessels, hemorrhage, and exudate.

Etiology.—Probably the most frequent cause of choroiditis is syphilis, inherited or acquired, although a certain proportion of cases occur in individuals of the strumous diathesis. The variety of choroiditis may be classified according to the etiological factors—syphilitic, tubercular, traumatic, etc. Knies states that "choroidal affections of an asthenic type are much more fre-

quent in hereditary syphilis than in other conditions." It is also attributed to eye-strain and nutritional disorders. The more acute forms in which the formation of pus is a prominent manifestation arise from direct infection by the entrance of foreign bodies or through perforating wounds, septic operations, perforating ulcer of the cornea, all forms of pyemia, and the infectious fevers.

Treatment.—Although each individual case requires special treatment according to its extent, duration, and character, all necessitate certain routine procedures as the pathogenesis of this disease is still imperfectly understood. The frequency of syphilis as a cause demands the prompt administration of mercury and the iodids to combat any of its morbid processes. The eye should be afforded absolute rest and protected from exposure to bright light by wearing bandages or dark glasses. Free purgation and blood-letting, and electric-light baths daily for one week, are also of value. The correction of any ametropia serves to lessen the congestion of the choroid. Suppurative choroiditis requires antiseptic lotions and other measures adapted for lessening purulent inflammation, but as this variety is but a part of a panophthalmitis, enucleation is usually necessary.

Prognosis.—In the suppurative forms of the disease, blindness is almost an invariable result, and the eyeball is shrunken to a marked degree. In the nonsuppurative varieties, while the prognosis is not so grave, there is a diminution of vision proportionate to the extent and location of the morbid process. Choroiditis in the macular region lessens visual acuity to a greater extent than does a more diffuse inflammation at the periphery.

For convenience in description, choroiditis may be considered as *acute* and *chronic*. The acute variety is usually suppurative in character, although an acute form of serous choroiditis is sometimes observed. Its causes are for the most part local. The chronic form is never attended by pus formation, and is subdivided into serous, plastic, sclero-choroiditis, and retino-choroiditis.

SUPPURATIVE CHOROIDITIS AND METASTATIC CHOROIDITIS

Suppurative inflammation of the choroid is characterized by the presence of a purulent exudate between the retina and the

choroid, which usually extends, infecting the vitreous and often the entire uveal tract.

Etiology.—It may be secondary to iritis or iridocyclitis, but in most cases follows the introduction of septic material into the eye either through penetrating wounds or by means of the blood stream.

Under perforating wounds may be mentioned the infection following the entrance of foreign bodies, sloughing and perforating corneal ulcers, unclean operations upon the eye, particularly cataract extraction, etc.

In the metastatic variety the infection carried by the blood stream is that associated with pyemia and the infectious fevers. Puerperal sepsis, endocarditis, septicemia, cerebrospinal meningitis, measles, dysentery, septic thrombosis and embolism, cholera, typhoid fever, gonorrhea, etc., may be factors in the production of this condition. The cases thus caused are usually classified as metastatic choroiditis. In one case of purulent choroiditis under the observation of the author the infection was traced to gonorrhea, and at the time of the appearance of the ocular condition gonorrheal rheumatism in both knee-joints was well marked. The patient died of general pyemia.

Symptoms.—The appearance presented by an eye the subject of this affection is that of a general inflammation of all the ocular structures. Early in the course of the disease it is possible to view the fundus and to locate areas of suppuration by their yellowish reflection, but soon the vitreous and lens become cloudy, so that a yellow reflex fills the entire pupillary area. Pain is present from the beginning, and the absorption of the septic material induces headache, malaise, loss of appetite, constipation, and elevation of temperature with an increase of the pulse-rate. Congestion of the anterior segment soon appears and the iris becomes discolored and sluggish in action. The pupil is widely dilated and the anterior chamber is shallow. The cornea is hazy and lusterless, and there is considerable pericorneal injection. Chemosis of the bulbar conjunctiva and conjunctivitis with a mucopurulent discharge are present. The eyeball becomes very hard during the height of the inflammation, but shrinks and becomes soft with its subsidence, constituting phthisis bulbi. The eyelids are greatly swollen and inflamed. The extension of the inflam-

mation is rapid and soon involves all the ocular structures, giving rise to the condition of panophthalmitis.

Treatment.—If the disease is the result of a local irritation, foreign body, dislocated lens, etc., the cause should be removed as soon as possible. If due to systemic metastasis, one may only hope to control the pain and try to lessen the suppuration by local blood-letting and ice compresses early. While enucleation is not advised as long as the cellular tissue is involved, my experience has been that enucleation should be performed as soon as the eyeball shows evidence of general inflammation of the inner tissues and light perception is lost.

The patient should be kept in a dark room. Mercurial inunctions or subconjunctival injections of cyanid of mercury (1-5,000) in doses from 10 to 20 cm., as well as large doses of calomel, may help to lessen the severity of the inflammation. The subconjunctival injections are very painful but must be insisted upon until 6 to 8 injections similar to the first have been employed. Darier, who is an enthusiast in this line of treatment, insists that subconjunctival injections of mercury have a specific action in diseases of the choroid, with opium for the pain and full doses of quinin to combat the septic injection. At this stage hot antiseptic fomentations aid in relieving the pain.

Prognosis.—The outlook is always unfavorable. Vision is invariably lost. Connective tissue forms between the various structures, causing them to be bound down in every direction. This undergoes contraction, inducing shrinking of the entire globe. When enucleation has not been performed and a shrunken eyeball results there is danger of a recurrence of the inflammation or sympathetic ophthalmia. Ossification of the choroid may also occur as a sequel.

Chronic suppurative choroiditis has been described by Fick and others, and very rarely occurs. It has no external manifestations and is detected by the yellowish coloration in the fundus when examined by means of the ophthalmoscope. It is often associated with pseudo-glioma (see Vitreous Diseases), and may be confused with true glioma of the retina.

Ossification of the Choroid.— This condition is not infrequently met with in eyes which have undergone atrophy and become shrunken. The bone formation is generally found in

the inner layers of the choroid. True osseous growths occur in the eye only as a consequence of plastic inflammation of the capillary layer of the choroid. These osseous deposits may appear in the form of small spots or plates, the process of ossification being identical with the formation of bone in periosteum. The pain produced by this condition may be slight, or it may be very severe, often giving rise to sympathetic inflammation. The author has invariably found bony growths in atrophied eyes of ten years' duration.

The eyeball should be enucleated.

NONSUPPURATIVE CHOROIDITIS—CHRONIC CHOROIDITIS

Serous Choroiditis.—Of this type of choroiditis two principal forms are distinguished—namely, one constituting acute inflammatory glaucoma, and the other, which is more simple throughout its course, involving the adjacent tissues to a far less extent. (The former will be considered under the subject of Glaucoma.) The latter form presents no marked objective symptoms, except, perhaps, very slight irritation, slight injection of the eyeball, and a diffuse cloudiness of the vitreous humor, in which a few delicate floating opacities may be seen. The intra-ocular tension is increased, and the condition may be mistaken for glaucoma, to which it may lead in time. Frequently the iris becomes discolored, the pupil somewhat dilated and perhaps slightly adherent, and the aqueous is secreted in larger quantity and becomes turbid, having small delicate particles of lymph suspended in it. After the subsidence of the simple serous choroiditis or choroido-iritis, examination with the ophthalmoscope shows that the humors have again become clear, and that no permanent changes have been produced in the choroid.

Plastic Choroiditis.—**Varieties** (*Choroiditis disseminata simplex; Choroiditis areolaris; Chororetinitis centralis or circumscripta, and Chororetinitis disseminata syphilitica*).

This form of choroiditis is usually binocular, and in its incipiency is hardly distinguishable by the ophthalmoscope from the normal fundus, with which the student is, of course, familiar.

The characteristic condition of plastic inflammation of the choroid can, however, only be studied with the ophthalmoscope. Hyperemia accompanies the acute stage of this disease, and the

patient may complain of "flashes of light," even though he is in a darkened room. The retina, lying in contact with the affected choroid, may become involved, thus leading to impairment of vision, and a sensation as of a cloud before the eye (positive scotoma). The lens and vitreous may also become opaque and further impair the vision.

When the disease has advanced to the later stages it presents the most striking and characteristic ophthalmoscopic appearances, which cannot fail to arrest the attention of even a superficial observer. This, however, is not the case in the earlier stages of the disease, especially at its commencement, since the small, round, grayish-white spots of exudation are very easily overlooked, even by the more careful and experienced observer. These round spots vary greatly in size, some being extremely small, while others are of considerable size. Later in the course of the disease these exudations are absorbed, and atrophic changes of the choroid ensue, the sclerotic becoming visible in places as white patches surrounded by girdles of black pigment. These girdles are caused by the absorption of pigment epithelial cells around the atrophic patches.

The disease extends from the periphery of the fundus toward the posterior pole of the eye, so that eventually the whole background becomes mottled with innumerable atrophic patches, of varying size and shape, surrounded by pigmented girdles, and, perhaps, separated from each other by healthy choroidal tissue.

The variety termed choroiditis areolaris is confined to the posterior pole of the eye, chiefly in the neighborhood of the yellow spot. The spots are large, oval, or circular in shape, of a white or yellowish-white hue, and choroidal vessels are faintly visible in their area. Although they are chiefly grouped around the yellow spot, they are separated from it by healthy choroidal tissue. These spots are encircled by broad zones of pigment, brownish or blackish in color.

Often it is noticed, that when the posterior pole of the eye is thus affected, a few spots of exudation are also scattered here and there at the periphery of the eye.

We cannot, with a certainty, diagnose the syphilitic form of choroiditis, though some authorities consider that certain lesions are more particularly characteristic of this type of choroiditis

than of the other forms. It probably shows itself most frequently in the form of numerous small, white, circumscribed patches, punched out, surrounded by a faint reddish zone, which exhibit little or no tendency to extend or coalesce, even when they are grouped closely together. The vitreous is peculiarly opaque, on account of very fine, dustlike particles floating in it.

Plastic choroiditis is also known as central choroiditis when the changes are most marked in the macular region. This is most common in elderly people, and seems to affect both eyes to the same extent. It is considered by some authorities to be one of the manifestations of senile decay of the vascular system. Vision is markedly diminished and central scotomata are present. The choroid is atrophied and there is a deposition of pigment around the macula lutea. Its occurrence in young people is attributed to syphilis or some other constitutional disturbance.

Diffuse choroiditis is also a subdivision or clinical type of this affection. It begins with cloudiness of the retina and vitreous with circumscribed exudation in the macular region. Later, the affected areas assume a dirty gray color and irregular outline, being eventually replaced by atrophic and pigmented patches. The cloudiness of the vitreous disappears and the vision, particularly color perception, is notably diminished. This variety is considered as syphilitic in orign.

Sclerotico-Choroiditis, Anterior Staphyloma, Anterior Sclero-Choroiditis.—This is the result of an inflammatory process in the choroid and adjacent sclerotic, frequently involving the cornea and iris, whereby the latter, becoming weakened, gives way under the normal or increased intra-ocular pressure. The staphyloma may be at any point, but it is generally at a short distance from the corneal margin, about the entrance of the anterior ciliary arteries. If the staphyloma is at all extensive, very serious consequences are almost certain to follow.

Myopic Choroiditis, Posterior Sclerotico-Choroiditis, Posterior Staphyloma.—The process which leads to the formation of a posterior staphyloma differs from that which results in an anterior staphyloma. In the latter case an inflammatory process is generally responsible for the condition, while in the former case it is usually conspicuous by its absence.

Anterior staphyloma is most frequently due to increased intra-

ocular pressure, and is usually found in children under fifteen years of age. Posterior staphyloma, on the other hand, is more common between the ages of fifteen and twenty-two years.

A large posterior staphyloma may continue, or may induce choroidal inflammation, or glaucomatous symptoms, and for these reasons the patient is in constant danger.

Posterior sclero-choroiditis is usually present in high degrees in myopia, and invariably in progressive myopia, and must be regarded as a grave complication of this condition. The affected eyes usually appear larger than normal, are prominent, and ovoid in shape. The antero-posterior diameter of the eyeball is increased, and the infundibulum or hollow, which is seen in the normal eye between the outer canthus and the globe, has disappeared. If the disease is extensive, the lateral movements of the eye are slightly curtailed, and the patient complains of a sense of fullness and tension of the eyeball, as if it were too large for its socket. The connection of glaucomatous symptoms with the stationary (noninflammatory) type of posterior staphyloma shows that the recession of the posterior pole of the eye acts as a preventive of glaucoma—a fact which, perhaps, is not often enough remembered.

Choroido-Retinitis.—Involvement of the retina is always present in extensive cases of choroiditis, particularly those due to syphilis. The symptoms are largely visual disturbances.

Treatment.—Before instituting treatment, it is, of course, desirable to determine the cause of the choroiditis. If there is a clear history of syphilis, or even if this is only suspected, the method of treatment to be adopted will be evident. In the simpler forms of choroiditis the treatment consists chiefly in the instillation of atropin and the application of blisters or 3 to 6 leeches behind the ear. Where inflammation exists in the deeper structures of the eyeball the leeches should be applied behind the ear on the side affected. The affected eye should be given perfect rest and guarded against exposure to cold and to bright light. Diaphoretics, as well as diuretics, often prove useful, and in all cases a " mixed treatment " will not be amiss, since this tends to hasten the absorption of the inflammatory products—the vitreous opacities. I have found very valuable in such cases the application of the constant current, 1–2 milliampères, with the nega-

tive pole to the eye, for five or ten minutes daily. Should the patient be anemic, it is well to correct this condition by tonics.

Examination of the visual acuity will disclose variations in the estimation of the size and shape of objects from time to time, and this is corrected to a great extent by the administration of mercury, iodids, and belladonna. The refraction is always unusual in character and also undergoes marked changes in very short periods, often necessitating frequent changing of glasses. The correcting lenses should be worn constantly to relieve the choroid of any additional congestion, such as follows eye-strain. In the more severe forms of choroiditis the use of atropin is not advisable, except where iritis coexists, on account of its tendency to produce increase of tension, which condition must, if possible, be avoided. Whenever there is marked increase of the intraocular tension, an iridectomy, or at least a paracentesis of the anterior chamber, should be promptly performed. If indicated, the latter operation may be repeated at intervals of three to four days.

In exceptional cases chronic choroiditis is attended by severe pain, relief from which is afforded only by the administration of narcotics and hypnotics such as morphin, chloral hydrate, paraldehyd, etc. Such cases are attended by progressive failing of vision, and occasionally resist all forms of treatment requiring enucleation for relief of the pain.

Prognosis.—The prognosis in diseases of the choroid must be guarded, and is, on the whole, unfavorable. In the serous type of this disease there is a greater chance of arresting the progress; in the other types, the best that can be hoped for is to afford relief to the patient while the disease is progressing. The plastic is not so serious as the suppurative type. Choroido-retinitis is grave as regards vision.

Macular Choroido-Retinitis.—Small punctate spots, from six to ten in number and of a yellowish-white color, symmetrically situated about the fovea centralis, have been frequently observed by the author in students of both sexes, from twelve to eighteen years of age, although it is frequently met with in other individuals following close work, such as printers, compositors, sewing girls, etc. Vision is usually reduced from 10 to 30 per cent, especially near vision. The author can only account for these inflammatory products as being due to eye-strain. This

condition is not only annoying to the patient, but to the ophthalmic surgeon as well, as these cases frequently resist treatment.

Treatment.—In the acute stage I have found the subconjunctival injections of cyanid of mercury (1–5,000), from 10 to 20 c.c. by means of a Pravaz syringe, to be of value. The pain caused by this injection is very severe, and to mitigate this the eye should be thoroughly anesthetized with holocain, cocain being insufficient. If the patient will not submit to a second or third injection (six to eight should be given), 2 to 4 grains of mercury with chalk should be given three times daily to the point of physiological tolerance. This treatment may be aided by the constant or high-frequency current, continued three times weekly for two or three months. In many cases all treatment fails because the anatomical elements were completely destroyed before treatment was begun. During treatment the eyes should be placed at rest by the use of a mydriatic, and the patient kept in a darkened room.

TUMORS OF THE CHOROID

Carcinoma of the Choroid.—The first case of metastatic carcinoma of the choroid was described by Perls in 1872. In 1903 Krukenberg brought the literature up to date, which was enlarged by Paul in 1905, to 52 cases. Nacht and Weishaupt have enlarged the literature to about 60 cases, while G. F. Suker and L. N. Grosvenor have now (1909) published a table of 64 cases (*Ophthalmoscope*, July, 1909). It will thus be seen that carcinoma of the choroid is very rare. It occurs either as a medullated or as a melanotic carcinoma. Carcinoma of the choroid is generally secondary to tumor of the breast. These tumors are not very easily diagnosticated, and in the diagnosis it should always be remembered that a carcinomatous growth develops more rapidly than a sarcomatous growth, leads at an earlier period to metastatic affections, and manifests a great tendency to involve the lymphatic glands.

On microscopic examination the medullary carcinoma is seen to consist of numerous areolar spaces, formed by the connective tissue, and within these spaces are contained the nests of cancer cells, the latter being variously shaped.

The melanotic variety is only distinguished from the medullary variety by the more or less considerable pigment contained in the cells and the trabeculæ forming the areolæ. This type of cancer is extremely dangerous, and after excision is very prone to recur at an early date.

At times this tumor is of a mixed variety, being a combination of sarcoma and carcinoma.

The treatment for these tumors is the same for both sarcoma and carcinoma—namely, the exenteration of the eye as soon as the diagnosis is established with a reasonable degree of certainty.

In the Finsen treatment of cancer the actinic rays of the arc-light are now being utilized with success, and it is possible that this form of treatment may be applicable in the variety under discussion. The application of the X-ray is also advisable.

Sarcoma of the choroid is the most common tumor of that structure, and may be composed of round or spindle cells. It may be pigmented (melano-sarcoma) or nonpigmented (leuco-sarcoma), the former being more common. It is essentially a malignant growth, being slow in onset, but later rapidly destroys all tissue in its neighborhood with the formation of a fungoid mass and similar metastatic growths in the viscera. Although it is usually encountered in middle-aged persons, it may develop at any time of life. Men seem to be affected with greater frequency than women, and the left eye is most often attacked. The growth is always primary, single, and involves but one eye. It develops from the connective tissue of the choroidal vessels (capillary layer) and remains encapsulated by the choroid

FIG. 106.—SARCOMA OF CHOROID.
(Author's case.)

for a comparatively long period. While Fuchs claims that all sarcomata have their origin in the deep layers of the choroid, Schieck has demonstrated that the nonpigmented and the pigmented may arise wherever connective tissue normally exists, or any layer of the choroid. It the early stages the tumor is circumscribed and spheroidal in form and is seen as a small nodular mass situated near the posterior pole of the eye to the outer side of the papilla. Occasionally it springs from the anterior or lateral portion of the choroid. Of greater rarity is the diffuse sarcomatous infiltration of the choroid reported by some observers.

In the very early stage it is impossible to state with certainty the exact condition present within the eye. Usually there are no symptoms to attract the attention toward that organ. The situation of the tumor may induce visual disturbances. Examination of the fundus at this period will reveal a condition not unlike that of detachment of the retina, but distinguished from it by the situation of the choroidal vessels immediately beneath the retina.

With the increase in size of the growth irritative or inflammatory symptoms arise of a glaucomatous character. Increased tension is present, together with pain in the eye and head, shallow, anterior chamber, anesthesia of the cornea, etc. Examination of the fundus becomes impossible on account of the cloudy condition of the media and the growth. Iridocyclitis and sympathetic irritation of the other eye may be induced.

A further increase in the size of the growth causes it to perforate the sclera, after which the tension falls and the pain is lessened. The growth progresses rapidly in this stage with the protrusion of a fungoid mass that involves all adjacent structures. Although it usually perforates anteriorly, it may do so posteriorly, when it results in marked exophthalmos. The optic nerve and brain may be attacked.

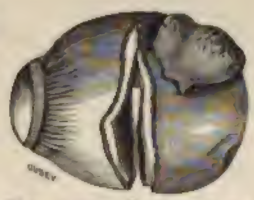

FIG. 107.—SARCOMA OF CHOROID. (Gross specimen.)

The last stage is characterized by the formation of metastatic growths in the internal organs, especially the liver. A fatal termination is not long delayed after the appearance of these growths.

Diagnosis.—Sarcoma is a condition that is very rarely met with in childhood, and this should be borne in mind in the differ-

ential diagnosis from glioma of the retina—the latter occurrin only before the age of ten or twelve years.

It is diagnosed from simple detachment of the retina by th reddish-yellow color, the appearance of vessels beneath the retina and the absence of the wavy motion of the detached retina floating on serous fluid, and from primary glaucoma by the reduction of intra-ocular tension; but it must not be forgotten that in the course of its intra-ocular growth the tumor may give rise to secondary glaucoma. Furthermore, sarcoma is unilateral as a rule. After the tumor has pierced the sclera, its sections may be recognized under the microscope, or by its abundant pigmentation, but this would be of very rare occurrence with present methods of diagnosis.

Treatment.—Complete removal of the eye is indicated. The spindle-cell variety may be permanently removed by this method, but the round-cell variety returns—often very promptly, though sometimes not for several years. The recurring growth generally is more rapid, and a secondary removal is necessay. The life of the patient is not materially prolonged by the removal of a round-cell sarcoma, but the pain may be abated and a respite secured. Cauterization or extensive destruction of tissue by Vienna paste probably retards the progress of the disease, but rarely cures.

If the growth cannot be entirely removed, treatment with mixed toxins of erysipelas and bacillus prodigiosus offers a slight chance of cure. The X-ray and Finsen-light treatment may also be tried.

Prognosis.—The outlook is always unfavorable. Death usually takes place within five years from the appearance of the growth when there has been no surgical interference. Recurrences have been reported as late as seven years after the removal of the affected eye. It is always impossible to determine the existence of small metastatic foci.

Tuberculosis of the Choroid.—This is a very rare affection. Tubercles appear as small, round, yellowish spots, which grow quite rapidly without pigment changes, rarely reaching the size of the optic disk. They occur usually in the last stages of acute miliary tuberculosis.

The treatment is principally a reconstructive one.

Sometimes a single large tubercle resembling a sarcoma is

observed, which produces the same destructive changes that a sarcoma would set up. If the patient's condition warrants it the eye should be enucleated, to prevent the spread of the tuberculosis to the other organs; but is of doubtful value.

The differential diagnosis of intra-ocular tumors is materially assisted by the following procedures: first, the magnifying glass, especially the binocular variety; second, the condensing lens for oblique illumination; third, the ophthalmoscope; fourth, the transilluminator; fifth, the exploratory puncture. Neoplasm of the interior of the eye can be seen occasionally by oblique illumination, generally by the ophthalmoscope, and the results con-

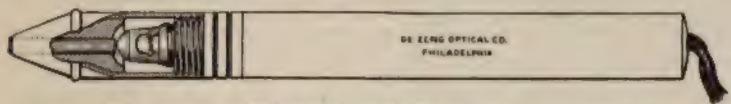

FIG. 107*a*.—WÜRDEMANN'S TRANSILLUMINATOR.

firmed by transillumination. The principle consists of the projection of a beam of light through the eye while in a dark room, by the use of such instruments as have been devised by Sachs of Vienna, Rochon-Duvigneaud of Paris, and the modification by Würdemann of this country.

The Sachs lamp consists of a 25-candle-power electric light which is covered and bears a cone-shaped projection extending from the side. This projector is made of solid glass cone, silvered around the circumference and surrounded by a hard-rubber shell to prevent the radiation of heat. Weaker lamps (5-candle-power) are, however, just as effective, and the operator is not confronted by the excessive heat or unwieldy bulk of the Sachs instrument. To use the lamp absolute darkness is necessary. The point of the cone is applied to the sclera previously cocainized, or against the upper or lower lid. It is necessary to manipulate carefully to obtain the correct illumination and the light must enter the eye at the proper angle. If the lids are held back the superior and inferior portions of the globe may be viewed. Würdemann's modification consists of a tube containing the light, in the end of which is a covered glass rod open at one end permitting the light to pass through; the entire instrument is not larger than a fountain pen and may be easily handled when applied to the eye, and the instrument is very popular in this country. If

there be any obstruction to the passage of the light through the eyeball, a shadow will be seen similar to those shown by trans-illumination of the maxillary antrum or nasal accessory sinuses when diseased. Exudates and tumors either of the anterior part of the choroid or ciliary body may be seen. Beginning ectasia of the ciliary area, atrophy of the ciliary body, foreign bodies, as particles of steel, show distinctly, the latter being visible with an opaque lens, under which circumstances the X-ray furnishes the only other method of detection. It is necessary, however, that they be sufficiently near the sclera to cast a shadow; neither should the vitreous be too densely infiltrated. It should be possible by this method to locate a lens luxated into the anterior part of the vitreous. Retinal detachments, owing to the slight intensity of the shadow cast, are seen with difficulty; however, if the lens be clear and the media too hazy to permit the use of the ophthalmoscope, they may be seen through the dilated pupil. Thus the transilluminator in experienced hands undoubtedly furnishes us with valuable information often unobtainable in any other way.

INJURIES OF THE CHOROID

Injuries of the choroid may result from direct or indirect traumatism. Direct traumatism is exemplified by the formation of perforating wounds by the entrance of foreign bodies and of incised wounds by cutting instruments. Foreign bodies should be located by the X-ray or the magnet, and removed as soon as possible on account of the danger of suppurative choroiditis and subsequent panophthalmitis. The eyeball, wound, and conjunctival *cul-de-sac* should be freely and frequently irrigated by antiseptic solutions.

Indirect traumatism consists in blows and similar injuries to the head and eyeball without the production of an open wound. As a result of such injuries, detachment, hemorrhage, or rupture of the choroid may result.

Detachment of the Choroid.—This condition has been reported only a few times. In choroidal detachment examination with the ophthalmoscope reveals a more or less globular protrusion in the vitreous of the eye. The surface of this small protrusion is free from wrinkles, being perfectly smooth, and here and there

presents small retinal vessels passing over its free surface from the normal fundus. The color of the mass varies from light yellow to dark red, depending upon the absence or presence of minute ecchymotic hemorrhages. The detachment of the choroid from the sclerotic may be caused by a neoplasm, or by an effusion of blood between these two layers of the eye.

The treatment has received very little attention, since such a small number of cases have been reported that the ophthalmologist has not been able to make a close study of the condition. Whether scleral puncture would prove of value is a question that remains to be determined by actual trial.

Choroidal Hemorrhage.—This is another very rare affection of the eye. The hemorrhage may be either deep or superficial; it may be produced by a traumatism, such as a blow, or a wound involving the sclerotic and choroid. It frequently occurs in diseases of the eye which disturb intra-ocular circulation—for example, glaucoma, posterior sclero-choroiditis, etc. It may also arise from diseases, such as scurvy, purpura, etc. The blood may be effused between the choroid and sclerotic, and, if the hemorrhage is large, cause detachment; the extravasation may be confined to the tissue of the choroid proper, or may take place between the choroid and the retina. In the latter case, if the hemorrhage is considerable, it may cause a retinal detachment, as will be explained in subsequent pages.

The differential diagnosis between retinal hemorrhage and choroidal hemorrhage is made only with difficulty. Choroidal hemorrhages are generally more diffuse and have not the flame-like distribution characteristic of retinal hemorrhages. When the hemorrhage is in the neighborhood of a retinal vessel, the latter may be seen to pass over the hemorrhagic area, and thus afford aid in making the diagnosis.

Idiopathic choroidal hemorrhage should direct the physician's attention to the patient's general condition.

Rupture of the Choroid.—Rupture of the choroid is the direct result of a blow on the front of the eye. Owing to the hemorrhage it is difficult to see the tear in the choroid with the ophthalmoscope immediately after the injury, and it is only after absorption of the blood that a yellowish streak (usually curved) is noticed in the posterior part of the eye, somewhere in the neigh-

borhood of the macula. This band afterwards changes from yellow to white and is usually outlined by pigment deposits. It may be possible to see two or more ruptures in the eye.

The retina itself may not be injured and the impairment of vision depends on the intensity of the lesion. The author has seen several cases in which the vision, at first seriously affected on account of the hemorrhage, regained its normal condition after absorption of the hemorrhage.

Prognosis may be said to be fairly good. If the rupture is broad and expanded, vision at that spot is lost and will not be regained; whereas, if the rupture is merely a rent in the choroid, vision may not be greatly interfered with, especially if the macular region is free.

Cicatricial tissue changes, if occurring in large numbers, have been known to cause detachment of the retina.

Treatment.—Leeches should be applied to the temple as soon as the condition is detected. Early in the affection the patient should be placed in bed, atropin should be instilled, and cold compresses should be applied. The boric-acid, sodium-chlorid, and camphor-water formula previously described should also be employed locally. Internally, mercury with chalk should be administered in 2-grain (0.13) doses three times daily. Later, gallic acid (10 grains (0.6)) should be given every four hours. Saline cathartics and potassium iodid may also be employed to aid in the absorption of the extravasated blood. Subconjunctival injections of normal salt solution are often of great value, or, what is better still, 10 c.c. of the following formula three times weekly:

℞ Sodii saccharati	gr. v;	0.3
Dionin	gr. xv;	1.0
Aquæ destillatæ	fl ℥j;	30.0

Misce.

CHAPTER XI

DISEASES OF THE RETINA

GENERAL CONSIDERATIONS

THE diagnosis of diseases of the retina is best made with the ophthalmoscope, and it is here that this important instrument finds its chief usefulness and opportunity to display its excellence. But the use of the ophthalmoscope is a rigorous test of the physician's delicacy of perception and fineness of judgment, to which his experience must undoubtedly be added.

It should not be inferred by the student of ophthalmoscopy that ophthalmoscopic revelations of departures from the normal invariably point to the existence of general disease, however strong the probability, since it is still more certain that there are numerous exceptions which should not be forgotten. For instance, we are aware of the fact that nephritic or renal disease may exist for a considerable period of time before there are any characteristic indications observable in the retina. Further, we know that in only a few cases does the retina show any lesion; and, moreover, we also know that the retinal picture deemed pathognomonic not infrequently exists without any affection of the kidneys. Such limitations, however, must not lead us in any way to belittle the transcendent value and importance of ophthalmoscopic retinal study.

Most retinal affections or diseases are classified as forms of retinitis. In treating the different diseases of the retina both local and general measures are instituted; the latter, indeed, in many cases are of the greater importance.

The chief indication of retinal disease is impairment of vision. In other diseases there are abnormal after-images, or deficient power of recovery from the changes produced by exposure to light, which may lead to impairment of vision in strong light, or its undue impairment in diminished light; these last-mentioned

conditions are known as day-blindness and night-blindness, respectively. Prolonged exposure of the eye to excessive light greatly impairs the sensitiveness of the retina; this is well shown in snow-blindness, a condition caused by the dazzling light reflected from snow on a bright winter day. An analogous condition is also produced by exposure to brilliant electric light.

Although a description of the healthy fundus and its anomalous appearances is given in detail under the discussion upon the ophthalmoscope (*q. v.*), a brief review of that subject at this time will aid greatly in obtaining a clear conception of the pathological changes in the retina.

The normal fundus varies widely in its pigmentation, and these variations, which are purely anatomical, are often responsible for errors of judgment in the novice.

The retina itself is invisible, though in some healthy persons (rarely over thirty years old) there is occasionally seen a beautiful phenomenon, known as the " watered " or " shot-silk " appearance—a shimmer which flits over the surface of the retina, or centers about the macula like a half-invisible halo. This is a striking illustration of the interference phenomena of light, and is caused by the reflections of the ophthalmoscopic mirror from the anterior and posterior retinal layers that reach the eye of the observer in different phases, and, if they were sufficient in quantity, would produce iridescence, such as is seen in mother-of-pearl or butterfly's scales. This phenomenon is more common in dark-haired individuals, especially among Indian children.

With the exception of anomalies, the macula contains no vessels visible to the ophthalmoscope, and it often requires considerable time before the fovea and macula can be distinguished from the rest of the eye ground. One may see the retinal vessels of his own eye by rapidly moving before his pupil a disk or stenopaic slit. The blood-vessels appear as if suspended in midair.

The arteries of the retina are relatively smaller than the veins, and show a light line running through their centers, which, if it exists at all in the veins, is much paler. No pulsation of the normal retinal arteries is observable, but venous pulsation is not infrequent. According to Lang and Barrett a normal venous pulse occurs in 70 to 80 per cent of individuals. Arterial pulsation may

be superinduced by glaucoma, and perhaps by pressure on the globe with the finger. It also occurs in aortic regurgitation, aneurysm, and in exophthalmic goiter.

In health the papilla (optic-nerve head) appears as a nearly round disk, with definite boundary, and has a clear reddish to a pinkish-white hue. The central depression, or cupping of the disk—"physiologic cup"—if present, may vary widely in degree without being abnormal, and in this physiological excavation the *lamina cribrosa*, resembling fine sieve wires, is plainly seen.

Opaque nerve fibers is a congenital peculiarity sometimes met with, which, to the inexperienced eye, may closely resemble the appearance of the retina in albuminuric retinitis. At the lamina cribrosa the axis cylinders of the optic nerve are usually divested of their medullary sheaths; sometimes, however, these are persistent, and, distributed upon the retina, produce white, cometlike patches radiating beyond the edge of the papilla. In slight cases they have no pathological significance, but increase somewhat the normal area of the blind spot, since the passage of light rays to the underlying retina is intercepted by the opaque sheaths. Rarely they may even involve the macular region (Hawthorne). In extreme cases amblyopia is present.

In a case observed by the author the opaque nerve fibers extended around the optic nerve 2 disk diameters in breadth without any scotoma of the visual field.

Since the normal retina is invisible, it follows that deviations from the normal condition are indicated by its becoming visible; and, as a corollary, it follows that whenever it becomes visible for the physician, it has *ipso facto* lessened the visual powers of the patient.

FUNCTIONAL ANOMALIES

Retinal Asthenopia.—One of the most frequent functional disorders of the retina is exhaustion of its nerve elements. It is always secondary to anesthesia, hyperesthesia, or paresthesia of that structure. Hysteria is a frequent cause, but excessive use of the eyes also often induces it. The condition is particularly frequent in dentists and others whose occupation subjects them to the glare of some highly polished surface. In dentists it shows itself

as *gold-blindness* and is uninfluenced by age.[1] The great stimulating effect of yellow upon the rods and cones is well known, and it is this excessive stimulation in these individuals that leads to exhaustion of the nerve elements. The earliest manifestation of the affection is central scotoma without obvious cause.

Treatment.—Suspension of all near-work is indicated. Tobacco, alcohol, and similar substances should be interdicted. The refraction should be examined under a mydriatic and correcting glasses prescribed. Although under ordinary circumstances a tinted glass may be considered harmful, in these cases it affords astonishing relief, and it is my custom to prescribe amethyst-colored lenses.

Under this heading may also be described the various forms of blindness occurring as a result of exposure to intense light and due to excessive stimulation and consequent exhaustion of the retina.

Amblyopia due to Direct Sunlight (*Solar Retinitis*).—This condition is especially likely to occur on the occasion of solar eclipses by attempts to observe the same with unprotected eyes.

Symptoms.—Immediately after exposure the following symptoms make their appearance: a dark or semidark spot in the center of the field of vision; a peculiar oscillatory condition of the scotoma which tends to persist indefinitely; metamorphopsia, central color scotomata, which may be of greater extent than the dark spot, etc.

The ophthalmoscopic examination reveals a translucent gray spot in the macular region surrounded by a ring of congestion. This is probably due to coagulation of the albumin of the retina, with vascular reaction, diapedesis of blood corpuscles, and pigmentary disturbances.

Treatment.—Hypodermic injections of strychnin should be administered at regular intervals. Absolute rest of the eyes should be enjoined, and plain, dark glasses should be worn. The application of leeches or dry cups to the temple is often very efficacious. The constant current, from 2 to 3 milliampères, is also of value. The instillation of eserin is frequently productive of most gratifying results. Amethyst-tinted lenses are of great benefit.

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[1] See author's paper on "Gold-Blindness," etc., *Dental Cosmos*, February, 1901. Also, paper on "Amethyst-tinted Lenses, Etc." *Jour. A. M. A.*, July 10, 1909.

Prognosis.—The outlook is always unfavorable, as the scotoma may become permanent. Complete recovery is very exceptional, but in mild cases a decided improvement may be expected if the appropriate treatment is promptly instituted.

Amblyopia due to Electric Light (*Electric-Light Ophthalmia*).—This condition is dependent upon the intensity of the light. It has been observed, however, that the ordinary incandescent light has no permanent blinding effect on the eye. If the light is very strong, and the individual looks at it for a long time, the same effect is produced as in the case of direct sunlight. The injurious effect of the electric arc light on the eye has been variously attributed to the chemical action of the ultraviolet rays, to the accompanying heat rays, and to dazzling of the retina. It has been shown that there is no coagulation of albumin of the retina. There is, however, an edematous condition of the retina, with more or less destruction of the nerve elements.

Symptoms.—Phosphenes (similar to the subjective light sensations from pressure on the eyeball), color scotomata, pain, irritation, *photophobia*, blepharospasm, and lacrymation.

Treatment.—The treatment in this condition is similar to that of the preceding affection, but the subsequent results are more gratifying.

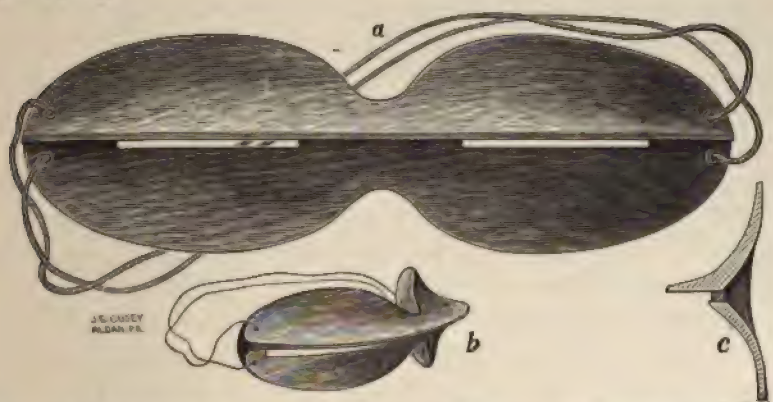


Fig. 108.—Goggles Used by the Alaskan Indians for Snow-Blindness, Made from White Pine Wood.

Snow-Blindness.—The exposure of the unprotected eyes for several days to the glare from an extensive surface of snow produces in some persons a peculiar form of ophthalmia, which may

be followed by temporary or even permanent amblyopia. The face blisters and the skin peels off, just as in sunburn. The attack begins with the sensation of a foreign body in the eye, photophobia, blepharospasm, or excessive lacrymation: later on chemosis, with small opacities or ulcers of the cornea, makes its appearance. In some cases there is a form of secondary hyperemia of the retina.

Treatment.—When there is risk of blindness, the eyes should not be exposed to the glare of snow or powerful electric light without being protected by smoked glasses. For the ophthalmia, cold applications and sulphocarbolate-of-zinc lotions are recommended to relieve the distressing symptoms. The following is of value:

℞ Acidi tannici	gr. iij:	0.2
Glycerini	fl ʒiij:	12.0
Aquæ rosæ, Aquæ destillatæ,	āā fl ℥ij:	60.0

Misce. Sig.: drop freely into eyes several times daily.

Alum may be substituted in the same proportion when tannic acid is not available.

The inhabitants of the arctic regions, who are exposed to the blinding glare of the vast snow fields, protect their eyes by a piece of pine wood which fits over the eyes, and has a narrow slit running horizontally before each eye, sufficient to give the individual a fair range of vision. The surface of the wood against the eyes is blackened, and the lids anointed with lampblack or charcoal and suet. It is very rarely that an Eskimo or Indian becomes snow-blind. The following facts are taken from a personal communication to the author from Alaska, where snow-blindness occurs extensively: (1) There is no definite period of exposure; persons going out well in the morning have returned snow-blind at night. (2) The pain is aggravated by heat of any kind. (3) Wet compresses (neither extreme of temperature) afforded most relief. (4) Blackening the skin of, and around the lids, has been found superior, in some cases, to any other kind of protection.

Prognosis.—The prognosis is quite favorable in the majority of cases; if, however, ulceration of the cornea takes place (and

this may assume a dendriform character), the outlook is most serious.

Anesthesia of the Retina.—A condition in which the sensitiveness of the retina is greatly diminished, characterized by a reduction in the acuity of vision and marked contraction of the visual field. There are no other symptoms, and the eye ground is normal in every respect. It may be classified as follows:

a. The affection is not infrequent, and is usually observed in children from six to fourteen years of age of both sexes. It is most common in the children of the better class of people. The acuity of vision is rather suddenly diminished, and this diminution is manifested by the child becoming awkward and by stumbling over objects not in the direct line of vision. An inability to read except in a very strong light makes its appearance in a very short time, and soon the direct vision is reduced. At this stage of the affection the ophthalmologist is usually consulted, and a careful examination of the visual field will reveal marked contraction varying from 30 to 55 degrees and the reduction of vision to one fifth normal. The color fields are contracted proportionately and maintain their relation to each other. Scotomata are absent. The ophthalmoscopic examination reveals nothing abnormal. The pupils are semidilated and somewhat inactive. The patients are usually in good health and have no symptoms other than great loss of vision. It is always of great importance to recognize this condition, as the appropriate treatment promptly brings about marvelous results.

Children between the ages of six and fourteen years are often subjects of neurasthenia, and this may be attended by ocular manifestations resembling anesthesia. In a typical case of amblyopia of neurasthenic origin the patient complains of momentary headache, blurring of vision, disappearance of print when gazed upon for any length of time, inability to read without holding the book or paper very close to the eye, and similar disturbances pointing to fatigue of the power of accommodation. Upon examination these patients will be found emmetropic with normal amplitude of accommodation, but without marked contraction of the visual field. In addition there will be found manifestations of the neurotic disturbance elsewhere in the body, such as periodic alterations in the disposition, hallucinations of hearing, in-

somnia, vertigo, twitchings, areas of altered sensation upon the body surface, frequently loss of body weight, etc. In these cases rest with tonic treatment brings about a cure, but even then the course of the affection is prolonged. In anesthesia of the retina there are no concomitant symptoms, and the response to treatment is immediate.

b. Nervous asthenopia is the term applied by Wilbrand, Fick, and others to a condition resembling in many particulars that just described as neurasthenic amblyopia. It is also attended by marked subjective symptoms, such as headache, lacrymation, blinding in a bright light, double vision, etc. It is hysterical in nature, and would seem to be due to hyperesthesia of the retina. It is readily distinguished from retinal anesthesia of the former class.

c. Hysterical amblyopia may be confused with retinal anesthesia, but hysteria does not restrict itself to contraction of the visual field and reduction of vision, and while there may be an element of hysteria in some of the cases of the latter affection, it is not fair to assume that the condition is always a form of hysteria in the absence of other manifestations of this disorder.

In the number of cases (25) of retinal anesthesia under my observation, which followed the course in the description (*a*), I am naturally led to consider it as a separate and distinct condition from those just differentiated from it. The novice may be misled into believing this class of cases to be secondary to some error of refraction, but recourse to the perimeter will correct this mistake in diagnosis. (See "Visual Fields" of W. F. Southard's case, *Pacific Med. Journal,* May, 1902.)

Treatment.—The application of the constant electric current is curative in class *a.* A weak current, 2 to 3 milliampères, should be employed, and the applications should be made daily. The negative pole should be placed over the eyeball and the positive pole over the opposite temple or nape of the neck. A period of ten minutes is sufficient for each sitting. The fields should be taken daily during the treatment, and marked improvement will be observed within a few days. Recovery is prompt after this treatment has been instituted. The same treatment, with the Weir Mitchell rest cure in selected cases, glycero-phosphates,

strychnin, and other nerve tonics and stimulants, is applicable to classes *b* and *c*.

Hyperesthesia of the Retina.—A condition in which the sensitiveness of the retina is greatly increased. Prior to the discovery of the ophthalmoscope this condition was usually mistaken for inflammation of the retina, and even at the present day it is yet erroneously described in some text-books on ophthalmology. Such an error in diagnosis is important, as it is followed by improper and injudicious treatment, and leads to an aggravation of the symptoms with an increase in the duration of the retinal hyperesthesia.

Etiology.—The affection is usually observed in young adults, and particularly in females of a neurotic or hysterical temperament. It is also associated with uterine disorders and menstrual disturbances. It may occur as a manifestation of hysteria, or it may be brought about by accidents, shock, blows upon the head or eyeball, prolonged use of the eyes in a very bright light, or even moderate exposure to an intensely dazzling light. Oxaluria is considered an important etiologic factor by De Schweinitz. Persistent headache, excessive venery, and congestive hyperesthetic areas in the nose and nasopharynx are also said to be causes.

Symptoms.—There are always present photophobia, lacrymation, and blepharospasm of varying degrees. The photophobia is often extremely intense, and may be suddenly induced by close application to near work.

The pain, a ciliary neuralgia, is very severe, and extends to the corresponding side of the face and head. The irritability of the retina is manifested by photopsia, and bright dazzling stars, colored rings, etc., are seen to float before the eyes. The retina retains images for an abnormally long period, so that the image of an object is perceived after the object has been removed from the visual field. The fundus is perfectly healthy and the refracting media remain perfectly transparent. Vision is very slightly, if at all impaired, and is rendered comfortable by wearing colored glasses. The intensity of the light is thus diminished, and reading at close range is aided considerably. The central vision is perfect, but the peripheral portion of the retina is anesthetic, so that the field of vision, as has been pointed out by von Graefe, is markedly concentrically contracted. At first glance the condition

seems to resemble amblyopia from toxic or other causes, but a careful examination will serve to make a distinction.

Treatment.—Rest is essential in all cases. When the photophobia is intense it may be necessary to confine the patient to a darkened room for a time, but usually the wearing of plane colored glasses will suffice to relieve this annoying symptom. Reading and other near work should be interdicted. Tonics and outdoor exercises aid also in restoring the ocular condition to normal. Turkish baths, massage, and static electricity are valuable adjuncts in the distinctly neurotic cases. The following formula as an eye lotion is very helpful:

℞ Acidi borici, Sodii chloridi, }	..............āā gr. xx;	1.2
Aquæ destillatæ	................fl ℥j;	30.0
Aquæ camphoræ	..............fl ℥iij;	90.0

Misce. Sig.: Drop freely into eyes three times daily.

For internal medication nothing has given the author such good results as the following pill:

℞ Strychninæ sulphatis	.... gr. ss;	0.03
Extracti aconiti, Arseni trioxidi, }	............āā gr. j;	0.06
Extracti belladonnæ	.... gr. ij;	0.12
Phosphori resinæ, 4-per-cent (Pile)	gr. xij;	0.80
Zinci valerianatis	.... gr. xxx;	2.00

Misce. Div. in No. xx. Sig.: One pill three times daily.

Paresthesia of the Retina.—A condition in which the sensations of the retina are altered or perverted. Such a condition gives rise to photopsia, inversion of the color fields, hallucinations of sight, and similar visual disturbances. It never occurs alone, but is always combined with other affections, particularly retinal hyperesthesia. As its underlying causes may be mentioned hysteria, neurasthenia, oxaluria, etc. The treatment is that of retinal hyperesthesia.

ORGANIC AFFECTIONS OF THE RETINA

Anemia of the Retina.—Anemia of the retina may be local or constitutional in origin. The former is most frequent and may be acute or chronic. *Acute anemia* of local origin arises from occlusion, compression, or spasm of the retinal arteries, as in migraine. It is particularly well marked in embolism of the central retinal artery. *Chronic anemia* of local origin usually follows some retinal disease in which atrophy of the vascular structures is a prominent feature. The constitutional disturbances that are accompanied by retinal anemia are general anemia, chlorosis, cholera, erysipelas, whooping cough, migraine, typhoid fever, and poisoning by drugs, such as lead, quinin, the bromides, and salicylates.

Symptoms.—These are blindness, temporary or permanent, according to the cause, with extreme narrowing and contraction of the arteries and pallor of the optic disk. Retinal changes occur in all chronic anemias and are manifested principally as hemorrhages and retinal plaques. They are very frequent and are disproportionate to the anemia. In malignant gastric tumors they are found almost constantly. These retinal changes are purely functional and devoid of any significance.

The direction from which the blindness approaches is of value in making the diagnosis according to some observers. Priestly Smith, for instance, states that retinal anemia is accompanied by blindness that approaches from above downward in contradistinction to the lateral blindness characteristic of cerebral involvement.

Treatment.—General anemic individuals should receive the usual course of hematinic treatment at all times. The occurrence of temporary blindness in the course of migraine or the infectious fevers may be relieved by the inhalations of amyl nitrite or the administration of nitroglycerin. Strychnin, digitalis, strophanthus, and other vascular stimulants may also be employed.

Hyperemia of the Retina.—An increase of the blood supply of the retina never occurs as an idiopathic affection. It is recognized by the increased redness of the optic disk with striations at its margins and dilatation of the larger blood-vessels. Owing to the variation in the width of the retinal vessels in health it is

extremely difficult to recognize the departures from the normal. Marked dilatation and tortuosity of the retinal vessels indicates hyperemia in most cases. Arterial hyperemia always precedes retinitis, but is seldom if ever detected. Venous hyperemia is most marked in heart disease, particularly mitral and tricuspid lesions, aneurysm, emphysema, and thrombosis of the central retinal vein.

FIG. 109.—SUBHYALOID HEMORRHAGE.

This represents the right eye of an elderly woman. This eyeground, with its myopia, shows a broad white crescent at the temporal border of its papilla; and the latter also has a rather large physiologic excavation. The retinal arteries are very tortuous, the veins normal. The middle of the fundus is occupied by a large hemorrhage, covering the region of the macula lutea, and extending upward as far as the superior temporal vessels, which are partially concealed by it. The lower part of the hemorrhage is dark red, and is separated by a sharp horizontal line from the upper, pale-red portion. This division into two parts is caused by the settling of the blood corpuscles to the bottom of the still fluid blood. In the vicinity of the large hemorrhage, especially at its upper and inner borders, lie numerous small spots of blood. These extend up to and upon the white crescent adjoining the optic nerve and up to the superior temporal vessels. From these vessels is derived the extravasated blood, which, after breaking through the limitans interna of the retina, passes between the latter and the vitreous, and sinks down to the region of the macula lutea, where even in the normal eye the connection between the retina and the vitreous is the least.

Etiology.—Among the general causes of active retinal hyperemia may be mentioned an undue filling of the peripheral circulation, such as occurs in pneumonia and sthenic fevers. Among the local causes are ocular inflammations, eye-strain, exposure to excessive light and heat, as well as thrombosis of the retinal vein.

Diagnosis.—The diagnosis is difficult, although the patients at times may complain of photophobia and visual fatigue. In most cases the condition must be inferred by the changes in the disk, although these are common to many affections.

Treatment.—As patients with retinal hyperemia rarely complain of symptoms referable to the retinal condition they seldom consult an ophthalmologist unless there are other ocular disturbances. The most frequent of these accompanying conditions is ametropia, and in such cases atropin should be instilled and the refraction carefully examined. In severe cases local depletion by means of leeches to the temples, and circulatory sedatives, such as aconite combined with bromids, internally, are useful. Constitutional derangements of any kind should of course receive appropriate treatment.

Edema of the Retina.—Serous effusion into the retina is present in all inflammatory conditions, particularly in albuminuric retinitis. It also follows contusion of the eyeball, in which condition it is characterized by transitory clouding of the retina. The acuity of vision is diminished to a corresponding degree, but this diminution is only temporary. Restoration to normal occurs within a few days in these cases.

VASCULAR ANOMALIES

Aneurysm of the Central Artery of the Retina.—This condition is characterized by great dilatation of the main branch of the central artery, or as miliary aneurysms (rare), which may be considered as indicative of the presence of others in the small arterial branches in the brain. It is extremely rare as an independent affection, but miliary aneurysms may be occasionally observed in hemorrhagic and albuminuric retinitis. Arteriovenous aneurysms are usually traumatic. No satisfactory treatment has as yet been devised owing to the infrequency of the affection.

Thrombosis of the Retinal Artery.—The formation of a clot or thrombus is also an uncommon affection. It may arise from a great variety of causes, among which may be mentioned failure of the heart's action with subsequent *slowing of the arterial flow*, disease of the vessel walls, and alterations in the quality of blood, or independent of these when the blood-pressure is low. The

condition is most frequent in the aged and may follow phlebitis and various pyemic conditions. It is preceded by transient attacks of blindness in the affected eye, and during the attack it is common for the vision to be greatly reduced if not absent in the unaffected eye. Headache, giddiness, and more or less faintness usually usher in the condition.

Ophthalmoscopic examination shows the fundus to be filled with hemorrhages and a swollen, tortuous, and turgid condition of the veins. The retina is swollen to such an extent that the outlines of the optic disk are greatly obscured.

Treatment.—In all cases of transient blindness careful inquiry should be made into the condition of the blood and circulatory system. Often by the early detection of some vascular disorder and its prompt treatment it may be possible to prevent extensive thrombosis. During the attack manipulation of the globe and paracentesis of the anterior chamber have been advised. The treatment suggested under embolism of the central artery (*q. v.*) is also recommended here. After the subsidence of the acute stage the iodids, gallic acid, and mercury should be administered for their absorbent and alterative effect. (See Hemorrhagic Retinitis.)

Thrombosis of the Central Retinal Vein.—This is also a very rare condition, and is met with chiefly in elderly persons with atheromatous blood-vessels and those who suffer from cardiac insufficiency. Inflammation of the cellular tissue of the orbital cavity from erysipelas or other causes may also produce thrombosis of the retinal vein.

Symptoms.—The retinal vessels are tortuous, the veins extremely thin, and the arteries greatly narrowed. The fundus is thickly studded with small dark-red hemorrhages which become absorbed and leave an atrophied retina with thready arteries. The optic papilla after a time becomes pale and atrophies. The affection is almost always unilateral.

Treatment.—The patient should be kept absolutely quiet, and put on a restricted diet, unless this is contraindicated by his general condition. Saline laxatives may be given, or venesection resorted to, which measures give the desired relief in some cases. Subcutaneous injections of strychnin have been mentioned as aiding in the treatment.

Embolism of the Central Artery of the Retina.—Obstruction of the central retinal artery is manifested by rapid blindness, beginning at the periphery of the visual field and advancing toward the center. The blindness may be total or partial, according as the occlusion of the vessel is complete or incomplete.

Etiology.—Valvular heart disease, especially acute endocarditis, arteriosclerosis, carotid or aortic aneurysm, pregnancy, Bright's disease, or chorea may induce the condition. Occasionally the embolus is pyemic in character and leads to suppurative retinitis and subsequent panophthalmitis. In some cases the underlying cause escapes detection. It is usually unilateral and may occur at almost any age.

Occlusion of the superior temporal artery has been reported (De Schweinitz).

Ophthalmoscopic Appearances.—Examination of the fundus within a few hours after the occurrence of the obstruction will reveal a pale and edematous condition of the entire eye-ground, most marked in the region of the disk and macula, becoming less pronounced as the periphery is reached. This cloudiness does not extend to the center of the macula, and at a point corresponding to the fovea it is entirely absent. The fovea is replaced by a bright cherry-red spot characteristic of this condition. It is due to the red color of the choroid shining through the thinned retina in this situation. The arteries appear smaller than usual owing to the diminished blood supply, and can be followed only for a short distance from the disk on account of the retinal edema. The veins are also contracted; but not uniformly, and present alternate contractions and distentions somewhat resembling a string of beads. The contraction is most marked near the disk, the vessels becoming more distended as they approach the periphery. Retinal hemorrhages may be seen especially in the macular region. Pressure upon the eyeball will give rise to the appearance of broken columns of blood with clear spaces between them. Occasionally it is possible to see such an intermittent blood stream in the veins without pressure on the globe. The color of the blood undergoes no characteristic alteration.

Course.—Vision is lost suddenly in all cases and may be complete or partial. If the main artery is obstructed even light perception will be lost, but if only a branch is occluded only that

... the retina supplied by that branch will be paralyzed, ... function of the other portion will be temporarily dimin- ... sometimes the visual acuity is very slightly affected in ... one of the branches. In the course of several weeks ... and the retina regains its transparency. It ... however, although no visible necrosis takes ... later period the optic nerve undergoes atrophic ... vessels become less in number and are thi... character. Occasionally an anastomosis exis... ... and some of the vessels of the anter... In such cases a collateral circulatio... ... time after the embolus has lodged ... of the retina is maintained, thus ...

... as the condition is recognized, ... any further changes in the eye ... has become dislodged spontane... ... Gentle massage shoul... ... view, and inhalation of a... ... dilatation of the ve... ... employed three times dail... ... should be enjoined to pre... ... and subsequent retinal ... ... to promote greater ... thrombosis than occ... ... ternal administration of ... an effort to hastily ab...

... thrombosis and embolus the ... is not restored withi... ... usually persists.

...MMATIONS OF THE RE...

... general term applied to i... ... very seldom idiopathic ... extension of inflammat... ... induced by constitu... ... hyperemia, and althoug...

dominance of some of the signs already given, and also by the characteristic appearance and grouping of the exudations. Frequently the choroid also becomes involved, giving rise to the term retino-choroiditis. Since retinitis is commonly the result of a constitutional disease, it may occur in both eyes, although not necessarily simultaneously, some time usually elapsing before the fellow eye shows evidence of the disease.

The most common cause of retinitis is albuminuria; probably next in order is syphilis. Brain diseases, diabetes, leucocythemia, various forms of intoxication (lead, phosphorus, etc.), disorders of the blood, etc., also contribute their quota as etiological factors in this disease.

SIMPLE RETINITIS

SYNONYMS: *Retinitis Simplex; Edema of the Retina.*

In this form of retinitis there is usually a clouding of the retina, either in small areas or involving a large part of the retina in the posterior pole of the eye. The superficial layers alone are affected. There is marked hyperemia, especially of the veins, which are dark and full, and often partly veiled by the haziness of the retina. Generally, only one eye is affected at a time, although both eyes may be affected simultaneously. There is impairment of vision over that portion of the field which corresponds to the portion of the retina involved. Hemorrhages are very infrequent. Atrophy of the retina is the sequel.

Etiology.—Simple retinitis may be the result of constant use of the eyes in fine work (eye-strain), exposure to cold, excessive light and heat, disturbed nutritive processes, menstrual disorders, etc.

Diagnosis.—The diagnosis is made by excluding the causes of the special forms of retinitis. As a rule, the different forms of retinitis commence much in the same manner, and simulate simple retinitis, their special characteristics being acquired later in the course of the disease.

Treatment.—Rest of the eyes in moderate light; correction of errors of refraction; use of mild purgatives, followed by iodids and mercury in small doses. The general health of the patient must be looked after.

ALBUMINURIC RETINITIS

SYNONYMS: *Retinitis of Bright's Disease (Papillo-retinitis).*

Inflammation of the retina occurs in about 30 per cent of all cases of Bright's disease and presents certain characteristics that serve to distinguish it from other forms of retinitis, and that render it a diagnostic factor of no little importance in renal disease. Norris states that 25 per cent of cases of nephritis possess characteristic retinal changes; Eales shows its frequency to be 28 per cent; Galezowski, from his observations, concludes that it occurs in 33 per cent of all cases. In the early stages of Bright's disease the retinal changes are so slight that they nearly always pass unnoticed, but as the affection progresses the peculiar infiltration, edema, exudation, and hemorrhages make their appearance, and the condition becomes unmistakable. Visual involvement was recognized by Bright himself in 1836.

The affection occurs with greatest frequency in those who are not incapacitated for their routine work by the kidney disease. One of the earliest symptoms is the loss of vision with headache, and for the relief of this symptom the ophthalmologist is consulted. Examination of the fundus reveals the characteristic retinitis, and the diagnosis can be readily confirmed by the results of frequent and thorough examinations of the urine. Very often these patients are unaware of any disturbance of their general condition until informed of it by the ophthalmologist. Although albuminuric retinitis may be seen in any form of kidney disease, it is encountered most frequently by the ophthalmic surgeon in connection with the cirrhotic kidney.

The age of the patient also exercises some influence upon the condition. The greatest number of cases is seen among middle-aged or elderly persons, but it is by no means rare to meet with it in the young. Bull has reported one case in a child five years old, and Anderson a case at nine years. The youngest patient with albuminuric retinitis observed by the author was eight years of age. In this case scarlet fever was the cause of the kidney disease, and there was double optic neuritis in addition to the retinal changes. The retinal condition in nephritis is usually bilateral in character, although unilateral cases are sometimes observed. According to Nettleship, males are more fre-

quently affected among adults, and *vice versa* in the case of children.

Albuminuric retinitis may be divided into two forms, acute and chronic. The acute form is more inflammatory in character than the chronic variety, and its predominating features are the swelling, congestion, and hemorrhages of the retina. The chronic form is degenerative in nature and is characterized by numerous spots and hemorrhages in the retina without any edema or congestion. In actual practice it is impossible to distinguish these varieties from each other on account of their association in varying proportions in nearly all cases.

The relationship between kidney disease and retinitis is not well understood, but the cause of the ocular disturbance is probably an extension of the degenerative changes in the vascular system to the small vessels of the tunics of the eye. The severity of the eye-ground symptoms seems to bear no fixed relation to the intensity of the renal disease, as the kidney affection may complete its course without any attention being directed toward the eyes.

On the other hand, while the retinitis is not an early occurrence in nephritis it may be the first symptom recognized, and its importance in this connection is very great. It is of diagnostic importance in these cases, and usually indicates a fatal termination in from six months to two years unless prompt treatment is instituted. The infectious fevers that are characterized by usual complications are not infrequently followed by retinitis. The kidney changes of pregnancy also exercise an influence in its production. The prognosis of these forms is more favorable, tending toward recovery, with subsidence of the nephritis.

The possible ocular conditions that may arise in the course of nephritis are as follows:

1. Complete blindness unassociated with visible ocular changes; uremic amaurosis.

2. Retinitis and neuroretinitis of a type peculiar to chronic nephritic disease.

3. Alterations in the caliber and relation of the retinal blood-vessels. Hemorrhages and exudates may or may not be present or may occur without changes in the vessel walls.

4. The uvea may undergo marked alterations, which manifest themselves largely by changes in the iris and choroid.

5. Lenticular opacities.

6. Impairment of function, and occasionally palsy of the extra-ocular muscles, particularly the superior oblique and the external rectus.

7. *Recurring subconjunctival hemorrhages.* These usually occur during the night and are discovered by the patient upon

FIG. 110*a*.—ALBUMINURIC RETINITIS. (Early stage.)

arising. At other times they follow unusual exertion, or walking against a strong wind is a not infrequent cause. Subcutaneous extravasation of blood frequently accompanies them. By many competent observers they are believed to indicate the actual existence of kidney disease, but in my opinion they occur as *premonitory* symptoms, being associated with generalized disease of the arterial walls, a condition that gives rise to the kidney affec-

tion. This conclusion was reached by the analysis of over 6,000 cases in the out-patient department of the Medico-Chirurgical Hospital. Of this entire number, 23 had recurring conjunctival hemorrhages, but the most careful ophthalmoscopic and urinary examinations proved negative in all, excepting that the urine in each case showed an excess of oxalates.

FIG. 110*b*.—ALBUMINURIC RETINITIS, SHOWING SNOW-BANK APPEARANCE. (Later stage.)

Ophthalmoscopic Appearances.—In order to fully comprehend the possible changes in the fundus in this condition one must recall the statement previously made that it is essentially arteriosclerosis of the smaller and, when advanced, of the larger retinal vessels. This aids in explaining the occasional occurrence of albuminuric retinitis before the development of symptoms referable to the kidneys. The retinal condition is really

an arteriosclerotic retinitis occurring as an ocular manifestation of both interstitial nephritis and generalized arteriosclerosis.

Mr. R. Marcus Gunn's (London) classification of the ophthalmoscopic appearance in arteriosclerosis and consequent chronic renal disease is of great interest and importance in this connection.

1. The course and caliber of the retinal arteries are altered, as is shown by the undue tortuosity and the changes in the size and breadth of the arteries. There may be general contraction of one or more arteries or alternate contractions and widening, causing the affected vessel to assume a beaded appearance.

2. The translucency of and the reflection from the vessel walls also undergoes marked changes. The loss of translucency is manifested by an inability to view any underlying vessel. White stripes are found along the vessels due to degeneration of the walls or infiltration of the pericorneal lymph-sheaths. The entire breadth of the artery assumes an unusually light color and the central light becomes more distinct than normal. (See Plate IV.)

3. The course and caliber of the veins are altered considerably, and are associated with signs of mechanical pressure. These changes are manifested by undue tortuosity, alternate contraction and dilatation, and an impeded venous circulation where crossed by a diseased artery. Ordinarily the crossing of a vein by an artery induces no pressure symptoms, and the translucency of the vessel allows a perfect view of the underlying vein. When the arterial walls are thickened by disease the vein is pressed upon or pushed to one side or its caliber is contracted, resulting in an ampulliform dilatation beyond the point of crossing. The venous walls are subject to the same changes as those of the arteries, resulting in white stripes and varicosities.

4. Retinal edema occurs, as shown by a grayish opacity, near the disk or whitish spots scattered through the fundus following the lines of the vessels.

5. Hemorrhages are frequent, and manifest themselves as linear extravasations along the course of the blood-vessels, rounded infiltrations, and subhyaloid hemorrhages. Absorption of the hemorrhage and subsequent atrophy is shown by the yel-

portion of the retina supplied by that branch will be paralyzed, while the function of the other portion will be temporarily diminished. Sometimes the visual acuity is very slightly affected in embolism of one of the branches. In the course of several weeks the edema subsides and the retina regains its transparency. It becomes atrophic, however, although no visible necrosis takes place. At a still later period the optic nerve undergoes atrophic changes. The retinal vessels become less in number and are thin and filamentous in character. Occasionally an anastomosis exists between the retinal artery and some of the vessels of the anterior portion of the eyeball. In such cases a collateral circulation is established within a short time after the embolus has lodged and the nutrition of a portion of the retina is maintained, thus preventing entire loss of vision.

Treatment.—As soon as the condition is recognized, efforts should be made to prevent any further changes in the eye-ground. Sometimes the embolus has become dislodged spontaneously and the circulation reëstablished. Gentle massage should be employed with this object in view, and inhalation of amyl nitrite should be prescribed to induce dilatation of the vessel walls. These measures should be employed three times daily for about ten days and absolute rest should be enjoined to prevent any increase in the arterial tension and subsequent retinal hemorrhages. Free venesection has seemed to promote greater absorption of the embolus and the resulting thrombosis than occurred in cases not thus treated. The internal administration of the iodids and mercury should be tried in an effort to hastily absorb the hemorrhagic *débris*, etc.

Prognosis.—In thrombosis and embolus the outlook is very unfavorable, and if vision is not restored within the first two or three weeks the blindness usually persists.

INFLAMMATIONS OF THE RETINA

Retinitis is the general term applied to inflammations of the retina, and these are very seldom idiopathic in nature. It may occur as the result of extension of inflammation from neighboring structures or it may be induced by constitutional diseases. It is always preceded by hyperemia, and although each form has cer-

tain definite characteristics, all present certain features in common. The term "retinitis," while technically meaning an inflammation of the retina, is still retained for various forms of retinal disease not characterized pathologically by "inflammation."

Symptoms.—Visual disturbances are always present. Visual acuity may be greatly diminished and scotomata are frequent. The visual fields may be irregularly or concentrically contracted. The light sense may be diminished, and micropsia, megalopsia, and metamorphopsia may be present. Pain is rarely a symptom, but the patient may complain of photophobia and ocular discomfort. The condition is usually bilateral.

Ophthalmoscopic Appearance.—The following are observed almost constantly:

Diffuse cloudiness, especially of the central portion of the fundus, due to loss of transparency in the retina, and consequent veiling of the choroid.

Congestion of the optic papilla, the general outline of which becomes more or less indistinct, and gives rise to a general striated appearance of the retina around the optic nerve.

Vascular engorgement, the veins becoming greatly distended or engorged and tortuous. The caliber of the arteries is unusually diminished.

Hemorrhages and whitish exudations follow the more severe cases, although the inflammation often subsides before this stage is reached.

Etiology.—The inflammation may subside with the return of useful vision, but more often the retina undergoes partial atrophy. A large number of cases undergo partial resolution and become stationary. This class of cases is often presented to the ophthalmologist on account of impairment of vision that cannot be improved by lenses. Examination of the fundus will show bright white patches, the edges of which may be pigmented, corresponding to areas of previous hemorrhage. Upon taking the visual field these areas will be represented by scotomata. The blood-vessels of the eye-ground will be found contracted after severe inflammation and atrophy of the nerve may also be detected.

The various forms of retinitis are differentiated by the pre-

subject to great variations on account of the intermittent course of the disease and of the frequent disturbing effects of treatment. The usual condition of the blood is one of moderate chlorotic anemia. The majority of cases show between 3,000,000 and 5,000,000 red cells and 40 per cent to 80 per cent hemoglobin."

The author has found this to agree with his observations in cases where edema of the face coexisted with edema and anemia of the retina, in which the blood examinations were made by Dr. W. C. Batroff, of the Medico-Chirurgical College Laboratory.

In chronic interstitial nephritis J. C. DaCosta, Jr., writes as follows: "So long as circulatory disturbances do not exist, the condition of the blood remains practically normal, but as soon as the compensatory hypertrophy of the left ventricle becomes inadequate, the blood changes identified with uncompensated valvular heart disease develop and various degrees of apparent anemia and polycythemia become evident from time to time." This, no doubt, accounts for the absence of albuminuric retinitis in this disease. We may have partial colloid degeneration, but not the retinal hemorrhages, since the blood nourishes the coats of the capillary blood-vessels of the retina, and thus prevents hemorrhage. The change in the heart's action soon produces angiosclerosis in these capillaries, which are the most minute in the body, and also produces changes in the nourishment of the intergranular layers of the retina, which show later as white striæ or colonies of fatty degeneration, and hemorrhages follow.

Diagnosis.—With the occurrences of changes in the eyeground, such as already described, it is safe in most cases to assume the presence of albuminuric retinitis. Confirmation of this diagnosis, however, is always necessary, and this may be readily obtained by a careful history of all symptoms, an examination of the urine in detail, the presence of hypertrophy of the left ventricle, persistent high tension with thickening of the arterial wall, anemia, and uremic attacks. The affection with which it may be confounded is neuroretinitis from other causes, but even then the condition is equally serious and the prognosis is extremely grave.

Retinitis Albumosuria.—The condition known as albumosuria, described by Bence-Jones and others, is accompanied by reti-

nal changes somewhat similar to those observed in albuminuric retinitis, so that one must be careful to make a distinction between these conditions on account of the difference in treatment and prognosis. Failure of vision is rather infrequent, but does occur. The patient more often complains of spots floating before the sight. In 4 cases, 3 whites and 1 negress, under my observation, the vessels of the fundus presented evidence of arteriosclerosis. In 3 of these cases the fundus reflex was yellow (pale saffron). Colloid dots were also seen above and below the optic nerve and white dots surrounded the macular region not unlike those of albuminuric retinitis. There were in addition hemorrhages and whitish deposits scattered throughout the entire fundus. In one case choked disk was observed, and in another a diffuse retinitis was present. From this description it may be readily seen that the essential feature of this condition is arteriosclerosis of the retinal vessels; this is also common to the retinitis of kidney disease, so that in all cases presenting evidences of degenerative changes in the arterial walls the urine should be most carefully examined for albumin and albumose in order to eliminate either of these factors, that the condition may be assigned to the other. (For an interesting account of albumosuria, with a review of the literature, see paper by James M. Anders, M.D., and L. Napoleon Boston, M.D., *Transactions of the College of Physicians*, Philadelphia, 1902.)

Treatment.—The patient should be placed in charge of a skilled clinician as soon as possible, who should be informed of the patient's condition from an ophthalmic standpoint. In the absence of such aid the patient should be placed at rest and general treatment begun. The anemia will indicate the use of iron, but its constipating effect will require considerable judgment to select the proper preparation. Basham's mixture is probably the best and is diuretic in action, in addition to being a tonic. Tyson cautions against the too free use of iron unless there be an actual anemia. Strychnin is of value on account of its effect upon the heart and blood-vessels. Gallic acid (5 grains (0.3) to 15 grains (1.0)) should be given three times daily, either alone for its hemostatic effect and to reduce the albuminous drain, or combined with mercury and chalk (3 grains (0.2)), to obtain the alterative effects of the latter. Free purgation and diaphoresis are of great advan-

tage in eliminating the poisons retained through the disability of the kidneys. Alkaline waters may be consumed in large quantities for their diuretic action. The diet should be regulated so as to prevent excessive ingestion of albumin, and the patient should wear woolen clothing the whole year around. Removal to a mild dry climate is advisable. All work should be interdicted.

The occurrence of headache, vomiting, and transient blindness always points to the onset of uremia and necessitates prompt measures.

Locally, very little can be done. The instillation of eserin has been advised, but it serves only to lessen the irritability of the choroid. Errors of refraction and failing accommodation should be treated in the usual manner as soon as compatible with existing conditions in order to diminish any tendency toward eyestrain. Rest of the eyes is of the utmost importance, as any congestion induced by attention to close work is liable to increase the number of hemorrhages.

Prognosis.—Vision is nearly always permanently impaired or lost, according to the number, extent, and situation of the hemorrhages. The outlook as regards life depends upon the character and stage of the nephritic condition. When seen in the early stages of Bright's disease, and appropriate treatment is carefully carried out, it is possible to prolong life for many years. The kidney disorders of pregnancy and the infectious fevers respond very readily to treatment. As ordinarily seen, however, albuminuric retinitis indicates death within two years after the appearance of the ocular trouble. If the hemorrhages in the retina are associated with fatty deposits (colloid) in a patient past thirty years of age death may be expected in from three to five months. Belts' statistics: In 155 cases in private practice 62 per cent died within one year, 85 per cent within two years, and 14 per cent lived more than two years. Out of the 175 hospital cases, 85 per cent succumbed within one year, 93 per cent within two years, and 6 per cent lived more than two years. Bull, in a series of 103 cases, found that 87 per cent died within two years. In my own experience I can recall one case that lived seven years after the colloid degeneration was recognized. In the albuminuric retinitis of pregnancy the prognosis as to life is not so grave.

SYPHILITIC RETINITIS

This form of retinitis, which, according to Alexander, is found in 8 per cent of syphilitic cases, may be due to acquired or hereditary syphilis; in the former case it may make its appearance a year or more after the infection. The initial stages present the same objective symptoms as albuminuric retinitis: Hyperemia, serous exudation, a gray or bluish-gray, filmlike veiling of the retina and papilla, increased tortuosity and dilatation of the veins, and proportional attenuation of the arteries. In the more advanced stages the white dots and spots about the periphery of the fundus are less brilliant and glistening than in the albuminuric type, and present greater variations. Opacity of the retina is most marked in a zone around the optic disk, or may be localized especially in the macula. Extravasations of blood, as a rule, are neither so frequent nor so pronounced as in albuminuric retinitis. Synchronous inflammation of the uveal tract, which is certain to take place, renders the diagnosis more positive.

Among the subjective symptoms may be mentioned: Diminution of central vision, which is observed in all cases, although in variable degrees; night-blindness or hemeralopia—i. e., excessive impairment of sight under weak illumination; a persistent dazzling or shimmering of light that is very annoying; contraction of visual field with scotomata. Metamorphopsia, and especially micropsia, attributed to the separation of the rods and cones by the effusion, are frequently observed.

Diagnosis.—When no other cause can be ascertained for a retinitis, the diagnosis of syphilitic retinitis should be made (Mauthner). This diagnosis will be confirmed by the finding of characteristic syphilitic lesions, or, negatively, by the absence of the other common cause of retinitis, in the majority of cases.

Treatment.—Mercury, preferably by inunction, the iodids given conjointly or alone, should be administered for a prolonged period. The constant current, 2 milliampères daily for five minutes, is of value. The attendant anemia requires the employment of tonics, such as iron, quinin, strychnin, cod-liver oil, etc. The eyes should be placed at rest and the refraction should be examined at frequent intervals.

Prognosis.—The vigor of the treatment, and the stage at which it is begun, have, of course, an important bearing on the prognosis. Vision generally improves under proper treatment, especially if the causal disease can be controlled. It must be borne in mind, however, that vision is very rarely restored to normal, and in the majority of cases retinal lesions are revealed with the ophthalmoscope. It may be stated that the prognosis is rather more favorable than in albuminuric retinitis. Syphilitic retinitis exhibits a great tendency to recurrence, and some stubborn cases result in partial or total blindness.

DIABETIC RETINITIS

Various observers have from time to time noted the occurrence of retinal inflammation in the course of diabetes mellitus, but no characteristic features have been described in the eye-ground appearance that would warrant using the retinitis as a diagnostic symptom of diabetes. It is not a frequent condition, and resembles in many respects albuminuric retinitis. Both eyes are ultimately involved in the process, but it may be late before the second eye is affected (Reik). The most common appearance of the fundus in this condition consists of small retinal hemorrhages with fine glistening dots above the macula. According to Berry, the changes are less marked in the macular region. Hemorrhages and opacities in the vitreous are more common than in albuminuric retinitis, and high myopia and cataract are often observed. Sometimes the appearance presented by the retina in diabetes is not unlike that of albuminuric retinitis. It is seldom an early occurrence in diabetes, but usually presents itself near the termination of the affection.

The symptoms are those of ordinary retinitis with the addition of the various manifestations of diabetes.

Diagnosis.—A distinction between this form of retinitis and other retinal inflammations cannot be made with certainty by the results of an ophthalmoscopic examination alone, but requires careful and frequently repeated urinary examinations. The urine may contain both albumin and sugar, but whichever predominates and is found more constant by repeated examinations may be considered as indicating the cause of the retinitis.

Treatment.—The various dietetic and medicinal measures recommended for diabetes must be employed immediately, particularly if the diabetes has remained undetected until discovered by the ophthalmologist. Salicylate of strontium or salicylic acid administered internally are of great value. Rest of the eyes is indicated, but no local treatment will be of any use whatever. The following has proved of value in the author's practice:

℞ Strontii salicylatis, Strontii bromidi,	...........āā	ʒij;	8.00
Glycerini	......................fl	℥j;	30.00
Aquæ menthæ piperitæ	.......q. s. fl	℥iij;	90.00

Misce. Sig.: Dessertspoonful in water three times daily after meals.

Prognosis.—Sight is always greatly impaired even in the most favorable cases. Usually the prognosis is very bad, as the disease is near the completion of its course when the retinal condition is detected. The outlook becomes more favorable in proportion to the degree in which the diabetes can be controlled.

HEMORRHAGIC RETINITIS

Hemorrhages may occur in connection with retinal inflammation, constituting *hemorrhagic retinitis*, or may take place independently, to which cases the term *retinal apoplexy* is applied. The condition which, as a rule, develops rather suddenly in the great majority of cases, affects one eye only; or, if both eyes are affected, one usually suffers more than the other.

Hemorrhages into the retina are common in many forms of retinitis. As a rule, they are found near the large blood-vessels, but their size, shape, and position admit of wide variation. Thus they may be generalized throughout the eye-ground or display a tendency to grouping in the region of the macula lutea or about the papilla.

Ophthalmoscopic examination will reveal numerous flame-shaped hemorrhages scattered throughout the fundus, which is slightly swollen and opaque. If a case is carefully observed fresh hemorrhages may be seen from time to time. White or yellowish spots or areas of pigment disturbance are usually present as the

essential in making a general diagnosis irrespective of the ocular condition. For details of the series [1] the reader is referred elsewhere. Eighty per cent of the above cases were found to have occurred in diseases in which hypertension is the rule, and if not a constant accompaniment the cardiac hypertrophy present would be sufficient that under extreme exertion or emotion the arterial pressure would be decidedly elevated.

By far the largest percentages of retinal hemorrhages were found in chronic interstitial nephritis, 40 per cent, arteriosclerosis second with 27 per cent, and chronic parenchymatous nephritis third with 13 per cent. The figures are suggestive in that it is to diseases of the *kidneys* first and of the *arteries* second that our attention should be directed when seeking the cause of a given case of retinal apoplexy. Anemia, simple, pernicious, and leukemia make up 6 per cent, there being 1 case of splenic myelogenic leukemia in which hemorrhage is rather uncommon, and 1 early case of pernicious anemia. In all but one instance there were hemorrhages of some type, and the blood-pressure with one exception was subnormal.

Singularly, the cases of lithemia (4 per cent) revealed only subconjunctival hemorrhages, in none was it possible to determine the presence of retinal hemorrhages, although the initial impression was that they would be found.

In two instances no other diagnosis could be made but that of intestinal auto-intoxication, there being vertigo, persistent drowsiness, and an excess of indican and skatol found in repeated urinalyses. Both were examples of hypertension, one showing hemorrhage, the other edema of the retina. Diabetic retinitis with hemorrhages furnished 2 cases; in both the blood-pressure was subnormal, they belonging to the toxic group of causes of retinal apoplexy. Secondary syphilis, a comparatively rare cause of these hemorrhages, was the etiologic factor in two instances; in one was an accompanying iritis, in the other beginning choked disk; in neither was the arterial pressure unduly high. In the single instance in which aneurysm was apparently the only ascertainable cause, one examination failed to note any gross abnormalities of blood-pressure, blood, or the kidneys.

[1] *Ophthalmic Record*, etc., September, 1908, "The Relation between Retinal Hemorrhages and High Arterial Pressure."

Of the hemorrhages that occur into the retina dependent upon alterations in the blood, a more complete study has demonstrated a pathologic condition of the individual red blood corpuscle in every instance. The structure of the cell being altered, its function is consequently impaired to a corresponding degree. As a result, the oxygen and nutritional carrying capacity ascribed to it is diminished. This deficiency affects mostly the vasa vasorum and the walls of the capillaries, which latter are nourished by the contained blood. This absence of nutrient vessels in the capillaries permits the walls of these structures to become involved in the degenerative process, and this is most manifest in the retina.

The involvement of the vasa vasorum may act as a safeguard, as the underlying condition is not permanent, and a return to health can usually be produced before any serious changes occur in them. With the impairment in nutrition of the retinal capillary walls, a probable thinning with weakening occurs and rupture with extravasation of blood becomes possible.

Examination of the blood at this time will show diminution in the amount of hemoglobin and reduction in the number of red blood corpuscles, with changes in their size, shape, and structure. In the series of 100 cases recently studied, the examinations made by Dr. Warren C. Batroff yielded the following results:

In 21 of the cases of retinal hemorrhage there was a decided reduction in the percentage of hemoglobin, only those presenting less than 75 per cent being considered as sufficiently anemic to affect vascular nutrition. The lowest hemoglobin reading encountered was 50 per cent, the smallest number of erythrocytes, 2,800,000 per cubic millimeter. The hemoglobin was uniformly proportionately lower than the number of erythrocytes, hence the individual corpuscle was decidedly poor in hemoglobin content. Leucocytosis was absent in all. Erythrocytes with decided endoglobular changes, as those with decoloration of the centers, or achromacytes, and general anisocytosis, or a decided smallness of the corpuscles, were the most common findings.

Symptoms.—Vision is always diminished, depending upon the situation and size of the hemorrhage. Hemorrhages in the periphery may be attended by little or no visual disturbance, while

a macular apoplexy will be followed by serious impairment of sight. Phosphenes and muscæ usually float before the eye, and in some cases everything seems unnaturally red. When examined by means of the ophthalmoscope, the hemorrhages appear as cherry-red spots, varying in color according to their location. If situated within the innermost layer of the retina the extravasation follows the direction of the nerve fibers and has a striated or flame-shaped appearance. When located in the middle or outer layer of the retina, the clot appears as a round or irregular blotch, in consequence of the blood following the supporting layers of Müller's fibers. A subhyaloid hemorrhage is present when the apoplexy occurs in the macular region between the retina and the vitreous.

Course.—At the outset of the hemorrhage the clot appears bright-red, but later becomes brownish-red or brown. As the extravasated blood is absorbed, the situation of the clot assumes a grayish or white appearance, showing that the retina is destroyed in that portion. These white areas may bear a resemblance to the areas seen in albuminuric retinitis, which, indeed, is frequently a cause of retinal hemorrhage. Their presence is indicated by scotomata in the visual field, and the loss of vision proportionate to their number and extent.

Treatment.—The measures usually advised are often wholly inadequate to stay the progress of the affection. Absolute rest for the eyes and body should be insisted upon. If seen within a few hours of the onset, cardiac sedatives, as aconite or veratrum viride, in small doses frequently repeated, are of value, particularly if there be an abnormally high arterial tension. Caution must be observed not to induce a too sudden or marked lowering of the blood-pressure, or irregularity of the pulse with cardiac failure may result.

Locally.—Bleeding from the retro-auricular tissues, cold application to the eyes, and a pressure bandage have been advocated, although their actual usefulness has been questioned. A weak solution of eserin, gr. ss (0.03)-℥ss (15.0), however, aids in reducing intra-ocular tension, and should be applied daily throughout the attack in elderly subjects. In those cases presenting high arterial tension, in addition to rest, exclusion of light, and the usual local measures, we have found that absorption of

the clot occurred far more rapidly (from one to three weeks earlier) by employing the following procedure: The patient is promptly bled from the median basilic vein while lying in the horizontal position, following the technic usually employed in venesection for any other condition. The sphygmomanometer is adjusted to the opposite arm and the pressure recorded every thirty seconds during the act of bleeding. It was found that it was rarely necessary to reduce it lower than 110 mm., for those with an original pressure from 150 mm. to 200 mm.; cases presenting systolic pressure of 200 mm. or over were seldom reduced lower than 150 to 160 mm. One is often compelled to desist before these reductions are obtained, owing to faintness of the patient. It is well at this point to add a word of caution that the aperture in the basilic vein should not be made so large that too great a volume of blood is suddenly lost, or a fatal syncope, with cardiac asystole, will result, this phenomenon being due to the sudden removal of the resistance to which a heart under high arterial pressure has been accustomed to functionate. If, however, the sphygmomanometer be employed, as mentioned above, this danger is entirely obviated.

In the less robust, somewhat anemic cases, we practiced relieving hypertension with the aid of the hot-air bath, electric-light baths, or even the moist pack, with caution. Pilocarpin sweats, while successful in the hands of some, we did not find as efficacious as bleeding. In the cases where bleeding is refused or impractical, extract. thyroidæ siccæ, gr. ij (0.12) t. i. d., combined with profuse diaphoresis, was found of value as a vaso-dilator. The later methods, while partially satisfactory, do not tend to produce the freedom from recurrence or the rapid absorption of the clot which characterized the cases upon which venesection is performed.

The author has recently observed a number of chronic nephritics, with whom retinal hemorrhages have been habitual at intervals of several months; these same individuals have been entirely free from attacks during the past two years following the above treatment. Although within twenty-four hours following the bleeding, the blood-pressure recorded was slightly higher than the elevation taken previous to venesection, there would invariably be a daily decline of approximately 10 mm.

per diem for three to five days, which latter pressure would usually be maintained for several weeks, and if fortified by suitable hygiene, months afterwards.

The conclusions to be deduced from the previously mentioned cases thus treated are, *that 80 per cent of retinal hemorrhages occur in individuals suffering from temporary or permanent high arterial pressure,* and that this excessive intravascular pressure is apparently the most frequent *exciting* cause; moreover, that bleeding has proven of value, not only in reducing dangerously high tension, but in acting as a powerful stimulus to a speedy absorption of the clot.

The routine treatment next in order is the regulation of diet; the nearer that approaches the lacto-farinaceous form the more satisfactory, and the quantity of food should be reduced to approximately 75 per cent or less of the customary meal. Meat, any variety, is permitted thrice weekly. Heavy and indiscriminate eating of rich and made-over dishes is calculated to provoke intestinal autotoxemia, with consequent spasm of the peripheral vessels.

Violent exercise, as running for street cars or ascending stairs, straining at stool, fits of anger or other profound emotion, must be rigidly interdicted.

Full doses of saline laxatives are to be employed once or twice weekly, notwithstanding the bowel action may be regular. Alkaline mineral water, as Vichy, etc., are of value in flushing the uriniferous tubules, provided the arterial pressure be not too high, or the intake of large quantities of fluid would aggravate this condition. The use of hot tub baths at 110° F. for ten minutes thrice weekly is both relaxing to the peripheral vessels and stimulating to the excretory function of the skin.

Medicinal Measures.—Gallic acid, while belonging to the class of systemic astringents, has in my experience best served to control the relaxed state of the muscular walls of the retinal arteries; this is particularly true in the markedly anemic cases. It is best administered in doses of gr. v–x (0.3–0.6) three times daily. It also is of value in the decidedly hemorrhagic cases where there is slow oozing from very minute injuries to the vessels. To promote absorption and as an arterial relaxant, the combination of sodium iodid, gr. v–x (0.3–0.6), with sodium

PLATE IV

1 2 3 4 5 6

1.—Eyeground in a case of chronic interstitial nephritis associated with arteriosclerosis, showing the "silver-wire arteries," the result of vasculitis and perivasculitis. (Author's case.)

2.—Macular (central) choroiditis. (Author's case.)

3.—Cribriform depression at macula with hemorrhage. (Author's case.)

4.—Connective-tissue changes following macular hemorrhage five years previous. (Author's case.)

5.—Papilloedema with retinal hemorrhages in a case of exceedingly high arterial tension (255 mm.). The arteries are obliterated, the veins full and tortuous, and the outlines of the disk effaced. (Author's case.)

6.—Embolism of the central artery of the retina. Sketch made forty-eight hours after blindness. (Author's case.)

nitrite, gr. j–ij (0.06–0.12), has been found of inestimable value:

℞ Sodii iodidi	ʒijss;	10.00
Sodii nitritis	gr. xxxij;	2.12
Aquæ destillatæ....... q. s. fl	℥iv;	120.00

Misc. Sig.: One to two teaspoonfuls one hour after meals, with ʒij (8.0) of essence of pepsin.

This I have been accustomed to give three times daily an hour after food for three weeks of each month, omitting, when possible, every fourth week. Spts. glycerylis nitratis, while useful for short periods, is too evanescent in its action and requires to be constantly increased in dosage, rendering the nitrite of sodium preferable. In distinctly autotoxic cases, and to some extent for its alterative and hematinic effect, hydrargyrum cum creta, gr. j (0.06) t. i. d., has fulfilled a very useful purpose. In consequence of its gently stimulating action upon the liver and intestinal antiseptic action, it has proven very serviceable in cases exhibiting marked indicanuria. Moreover, used in conjunction with the iodids, it materially accelerates absorption of the clot.

The author has had under observation a case in which the retinal hemorrhage persisted for three and a half years under treatment before recovery.

Cases due to leukemia, pernicious anemia, symptomatic anemia, diabetes, or syphilis, are of course not treated by venesection, but with the usual agents employed for such affections.

Prognosis.—This depends upon the severity and cause of the hemorrhage, as well as its position, and upon the patient's general health. The outlook is bad if the macula lutea is involved. If there is extravasation of blood into the vitreous, there is considerable danger of a subsequent rise of tension, which may cause a particularly intractable form of glaucoma—a frequent complication. There may be detachment of the retina, and scotomata which usually are permanent. In elderly subjects there is also the danger of cerebral hemorrhage to be considered. The oculist, being the first physician to be consulted, should study these patients with the internist, in order that the most comprehensive knowledge possible be available for the sufferer. They are

often, as most of us know, quite robust and enjoying the best of health, in so far as their knowledge goes, and only in the latest stages, when tangible subjective symptoms appear, can they be persuaded to relinquish their activities and excesses. It is thus, by this timely interference, that many years of vision, and even life itself, may be saved these individuals.

PURULENT RETINITIS

Purulent retinitis is a septic inflammation of the retina characterized by circumscribed whitish areas of fatty degeneration and suppuration in the macular region and near the papilla. It is usually bilateral in character, and occurs most frequently in the course of pyemia, puerperal sepsis, and similar conditions, endogenous (metastatic) purulent retinitis. It is sometimes associated with purulent choroiditis, but usually precedes this affection. Neuroretinitis as a result of gonorrheal metastasis has been described by Panas, Burchardt, Kurka, and others.

Etiology.—The affection is always due to the presence of pyogenic microörganisms in a retina already debilitated by injury or disease. These microörganisms may gain access to the tunic through a penetrating wound produced by a foreign body (exogenous purulent retinitis), or they may be carried to the retina in septic emboli by the blood current. In the former instance acute purulent retinitis is brought about as an independent affection; but in the second, suppurative choroiditis is induced at the same time, giving rise to embolic panophthalmitis. Panophthalmitis is the termination eventually in both classes of cases.

Diagnosis.—In the early stages it is extremely difficult to distinguish the affection with certainty. Ophthalmoscopic examination in every septic case would probably reveal the presence of whitish spots and hemorrhages scattered throughout the fundus. Most cases, however, come under the care of the ophthalmologist after panophthalmitis has appeared and the diagnosis is made only by inference.

Treatment.—The underlying septic condition should receive the treatment usually prescribed for such conditions. Rest of the eye with the application of cold compresses is always indicated. Inunctions of mercury, leeching, and free purgation aid in check-

ing the morbid process. Enucleation, however, is nearly always necessary.

Prognosis.—The eyeball as a visual organ is always destroyed. The outlook as regards life depends upon whether the general treatment is efficient in checking the causal septic condition. The best that can be hoped for is a useless eyeball that sooner or later requires enucleation.

LEUKEMIC RETINITIS

Leukemic retinitis is a very rare form of retinal inflammation first described by Liebreich, and is associated exclusively with splenic leukemia. The affection is bilateral in character, but one eye is usually involved to a greater extent than the others. Failure of vision in the course of leukemia is the first symptom that attracts the attention to the eyes. Examination of the fundus will reveal a diffuse retinitis with generalized swelling and opacity of the retina. The eye-ground is pale yellow or orange in color. The optic disk seems somewhat swollen and its edges are obscured. There is more or less pallor of the surface of the papilla. Upon following the course of the blood-vessels the veins will appear broad, distended, and of a rose-red color, while the arteries will become narrow and orange-yellow in color. The choroidal vessels when visible will present a yellowish-red tint. In the region of the equator, and also near the macula, there are often seen more or less elevated whitish spots with hyperemic borders. These areas result from an aggregation of lymph-corpuscles, while the more highly colored border is due to an extravasation of red blood cells. Hemorrhages when they do occur are usually peripheral, but when in the neighborhood of the macula may serve to confuse the condition with albuminuric retinitis.

Diagnosis.—The appearance of the fundus is usually characteristic, and hemorrhages may be distinguished from those of retinitis albuminuria by their more red color and greater distribution in the periphery. Urinary examination may show albumin and casts in the urine in both cases, but the other characteristic elements of nephritis will serve to make the diagnosis. An examination of the blood should be made in all doubtful cases. In leukemia, the anemia, and the enormous increase in the number

of leucocytes with the presence of eosinophiles and myelocytes will serve to make a distinction.

Treatment.—The treatment should be directed toward the underlying leukemia, and arsenic and stimulants should be freely prescribed. Local treatment is useless.

Prognosis.—The retinal condition shows no tendency to undergo involution, but persists as long as the disease of the blood lasts. It assumes a very chronic and somewhat stationary character, so that vision may be retained until death occurs. The leukemia ends fatally in about two or three years in spite of the most skillful treatment. Blindness sometimes occurs before the end of the affection is reached. A case of this character, a patient of Prof. W. C. Hollopeter, was examined by the author at the Medico-Chirurgical Hospital.

ANEMIC RETINITIS

Closely allied to the foregoing retinal condition is the retinitis seen in pernicious anemia. Biermer himself noticed hemorrhages in the retina in 1868. It is manifested by a generalized edema of the retina with numerous hemorrhages. These extravasations of blood have white or gray centers. The entire eye-ground has a yellow appearance, and the head of the optic nerve is discerned as a dirty white spot. The veins are distended and the blood they contain resembles arterial blood.

Diagnosis.—The ophthalmoscopic appearances, while strongly suggestive of this condition, are not diagnostic, and an examination of the blood is necessary as a confirmatory test. The pernicious variety of anemia is indicated by the decrease in number of the red blood cells, many of which present deformities of size, shape, and nucleation, along with a relatively increased percentage of hemoglobin.

Treatment.—Here, as in most forms of retinitis, the treatment is entirely constitutional. Those measures intended to increase the constituents of the blood and restore tone to the body are indicated. Local treatment is of no avail.

Prognosis.—The retinal condition is not a very active process and tends to remain stationary for a long period, as in the preceding variety. Usually death occurs in from one to two years,

but occasionally recovery takes place, so that treatment should be kept up until the end.

GOUTY RETINITIS

This variety of retinitis occurs in elderly individuals, who are also subject to other manifestations of gout.

There is impairment of vision, usually affecting both eyes, and indicated by yellowish-white spots, or patches of exudation, in the region of the disk and macula. In some cases there are hemorrhages of the retina, especially through the equator of the eyeball. In this form of retinitis there is marked contraction of the arteries and dilatation of the veins; the latter do not, however, present grotesque tortuosities, as in albuminuric retinitis. Moreover, the vessels throughout the body present evidences of marked angiosclerosis.

Examination of the urine reveals an excess of uric acid, both chemically and microscopically; casts are absent and albumin rarely found.

Treatment.—From the beginning our attention ought to be directed to the gouty diathesis; the administration of antilithics and gallic acid is therefore indicated. The eyes should be bandaged in order to afford them absolute rest. The patient must avoid all manner of excitement. Failure of accommodation or errors of refraction should receive careful attention.

Prognosis.—Blindness does not usually occur in this form of retinitis, but if vision should once be lost, it cannot be restored. It is a well-known fact that fatal cerebral hemorrhage terminates the majority of cases in this constitutional affection.

UNCOMMON CLINICAL FORMS OF RETINITIS

A number of cases of retinitis have been described by various authors that present distinct ophthalmoscopic differences, but which cannot be attributed to any one constitutional affection in each case. The principal of these forms are *retinitis circinata*, *retinitis striata*, *retinitis proliferans*, *retinitis punctata centralis* (*retinitis punctata albescens*), and *angioid streaks* in the retina.

Retinitis Circinata.—Before Fuchs described this affection in 1893 under the term "retinitis circinata," the disease had been

recognized clinically by Hutchinson, Goldzieher, De Wecker, and others. It is characterized by an annular, crescentic, or oval arrangement of slightly elevated, white or yellowish-white spots around the macular region, the distribution of the spots sometimes assuming the shape of a wreath. Hemorrhages may take

FIG. 111.—RETINITIS CIRCINATA. (Author's case.)

place into the retina, and in Fridenberg's case a formation of new blood-vessels in the retina was observed. Spots are sometimes seen on the nasal side of the disk. One or both eyes may be affected. A central scotoma usually exists. It is usually more frequently seen in women than in men. The precise etiology is unknown. There has been considerable discussion regarding the pathological alterations represented by the spots, some believing them to be due to a coagulation of exudate (Fuchs), others to arteriosclerosis (Goldzieher), while De Wecker considers them a

fatty degeneration of blood due to hemorrhages. The prognosis is unfavorable, the process being a degenerative one. Treatment is of no avail.

Retinitis striata is characterized by yellowish-white or gray streaks radiating from the head of the optic nerve to the periphery, occasionally with pigmented borders. Its origin is unknown.

Retinitis proliferans is distinguished from these other unusual types of the development of dense vascularized masses of connective tissue. These masses are whitish in color and take their origin from the retina, subsequently projecting into the vitreous and in some cases extending toward the ora serrata. They may be very extensive and obscure the disk and adjoining fundus. As complications of this condition may be mentioned newly formed blood-vessels, hemorrhages, retinal detachment, and vitreous opacities. Syphilis is believed to be the underlying cause in most cases.

Retinitis punctata centralis (*retinitis punctata albescens*) is an affection of the retina in which numerous small white pin-point spots are scattered throughout the periphery and macula, but which do not involve the blood-vessels. A grayish appearance of the papilla may be observed and more or less central diminution of vision is noted. It frequently begins in early youth, though it may be seen at all ages. It is not uncommonly encountered in several members of the same family. Night-blindness and contraction of the visual field is an accompaniment.

Angioid streaks in the retina have also been described and consist of pigmented striæ throughout the fundus resembling a system of obliterated blood-vessels. Their true significance is unknown. According to Lister these striæ may have been formed as the result of newly formed vessels. Vision is seldom altered to a marked degree.

Symmetrical Infantile Macular Changes.—In that peculiar condition known as "amaurotic family idiocy" it is common to find changes in the macula that are characteristic of this condition alone. It was first described at the Ophthalmological Society of the United Kingdom by Waren Tay in 1881, and studied by Sachs of this country from its neurological standpoint. Both

maculæ are involved, and the appearance of the fundus is somewhat similar to that seen in embolism of the central artery. Optic atrophy takes place, and is followed by gradual loss of sight. There is a white zone in the macular region of both eyes, with a cherry colored spot in the center. The affection begins in infants, and is attended by muscular weakness and general enfeeblement, terminating in death within one or two years. It occurs with frequency in children of the same family, more often affecting those of Jewish parentage.

Treatment is of no avail.

PIGMENTARY DEGENERATION OF THE RETINA

(Retinitis Pigmentosa)

A degenerative condition characterized by an excess of pigment with atrophic changes in the retina. There is hyperplasia of the connective tissue of the vessel walls, causing them to become considerably thickened. The vessels of the choroid also undergo a similar change by reason of a chronic endarteritis. The affection is believed to begin in the choroid, the pathological changes in which cause migration of the pigment from the pigment epithelium into the retina.

Etiology.—A great number of the cases are congenital in origin and make their appearance between the years of fifteen and twenty. The influence of heredity in producing this affection is undoubted, as it often occurs in several members of the same family, especially where there is a consanguinity of parentage, although the latter is not always the case. Patients with this condition are not uncommonly deaf and dumb or possess anomalies, such as supernumerary digits, harelip, cleft palate, etc. It is encountered with greatest frequency in the lower walks of life, and is not rarely accompanied by mental impairment or idiocy. It is almost always bilateral and may arise without any assignable cause. Robert C. Moon, of Philadelphia, reports a unilateral case (*Annals of Ophthalmology*, October, 1904).

Symptoms.—Vision is always impaired, and this is noticed at the age of puberty or shortly afterwards. One of the most prominent symptoms is the inability to see in the dark or even in a feeble light. This gradually becomes worse until vision is so

greatly reduced that the patient is able to see only when the object is placed directly in front of the eye. Coincidently with this is the contraction of the visual field, which becomes so marked that only a central portion of the field remains. The patient may be able to read at this stage, but there is a great inability to find his way alone. The condition is extremely chronic. The progressive diminution in vision and contraction of the visual field eventually end in complete blindness, although where the macula remains unaffected for a long time, more or less vision may exist for certain periods.

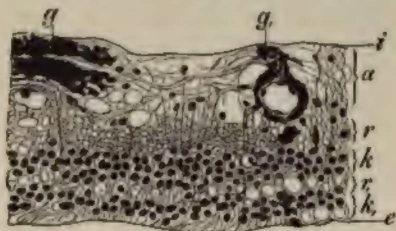


FIG. 112.—RETINITIS PIGMENTOSA. Section through the retina. Magnified 170 × 1.

The retina is bounded on its anterior surface by the membrana limitans interna, i, upon its posterior surface by the membrana limitans externa, e, the layer of rods and cones that succeeds the latter has disappeared altogether as a result of atrophy. Succeeding the limitans interna is a coarse-meshed network, a, which has originated from the supporting tissue of the retina. The nerve fibers and ganglion cells, which normally are inclosed in this supporting tissue, have been completely destroyed. The vessels, however, can still be seen and are inclosed in pigment. One of them, g (very greatly contracted), has been divided longitudinally; another, g_1, transversely by the section. The succeeding layers of the retina—namely, the inner reticular layer, r, the inner granular layer, k, the outer reticular layer, r_1, and the outer granular layer, k_1,—are altered, and here and there contain pigmented cells.

Ophthalmoscopic Appearance.—The fundus presents a peculiarly characteristic appearance in this condition that serves to distinguish it from syphilitic chororetinitis and similar affections, especially the character of the pigmentation. One of the most striking features is the presence of numerous stellate branching masses of black or brown pigment, resembling bone corpuscles in shape, scattered along the blood-vessels throughout the periphery of the fundus. Sometimes the vessels seem to be incased in this pigment. As the condition advances pigment masses are formed within those already mentioned, gradually contracting the area of the fundus not involved. The loss of pigment from the pigment layer of the retina allows the choroidal vessels to become plainly visible. The head of the optic nerve presents a yellow, waxy appearance, and gradually becomes atrophic. The retinal vessels become small and considerably contracted and atrophy of the retina takes place. At the posterior pole of the crystalline lens it is by no means infrequent to encounter a star-shaped

opacity in addition to the retinal changes. Occasionally cases are observed in which the pigment is normal in amount and distribution, and in others the distribution only is atypical. Retinitis pigmentosa may be readily distinguished from syphilitic chororetinitis by the patches of choroidal atrophy and the later appearance of the latter affection.

Treatment.—Although treatment is of very little avail, it should always be instituted. Internally, antisyphilitic remedies should be tried, and tonics, such as strychnin, iron, etc., should be given in full doses. Errors of refraction should be corrected, and the eye should be protected from excessive light or sudden variations in the illumination by wearing amethyst-colored glasses, in which the ametropic correction is constantly incorporated.

Cases have been reported in which the progressive contraction of the field was arrested by applications of the constant current, and useful central vision maintained. During my term at Moorfield's Eye Hospital, London, 1881–'82, I had the opportunity to test the efficiency of this treatment in a number of such cases, and the improvement was marked, consisting in enlargement of the visual field and improvement in central vision. Its persistent use three times a week, extending over years, is therefore indicated.

Prognosis without treatment is serious, the majority of patients becoming hopelessly blind at from thirty to fifty years of age. The spurious or syphilitic variety is more or less amenable to treatment, and the prognosis is not as unfavorable. In a case of Pyle's there remained noteworthy compensatory development of touch, hearing, estimation of distance, and sense of location.

ATROPHY OF THE RETINA

Atrophic changes in the retina may occur from a number of causes, and give rise to certain characteristic appearances. The head of the optic nerve becomes pale and of a yellowish or brownish color. It assumes a hazy appearance, and its outlines are ill-defined. The retina loses its transparency and also becomes hazy. Marked pigmentation is usually present, but it may be absent. The walls of the blood-vessels become thickened as the result of

an overgrowth of connective tissue, but later become narrow from the contraction of this new fibrous tissue.

All the layers of the retina are involved after conditions, such as retinitis, chororetinitis, pigmentary degeneration of the retina, and syphilis of the choroid and retina, but the outer layers are attacked first.

After optic atrophy, optic neuritis, glaucoma, etc., the atrophic process affects only the layer of nerve fibers and ganglion cells, leaving the outer layer intact.

In a typical case of essential atrophy of the retina in the advanced stage the appearance of the eye-ground differs in many particulars from other pathologic fundus conditions. The nerve head is atrophic and rather well defined, but instead of the white color commonly associated with optic atrophy the disk may be said to have a putty color. The retinal vessels are absent from the papilla, having been totally obliterated by the atrophic process. Here and there throughout the fundus a retinal vessel may be occasionally encountered as a thin red streak. The filmlike structure of the retina that normally obscures the outlines of the choroidal vessels is entirely absent except where it stretches across the choroid as thin filamentous bands, inclosing small aggregations of the remnants of the retinal pigment. The absence of the retina exposes to view the vessels and pigment of the choroid in their entirety, so that upon first gazing into the eye the observer is struck by the remarkable preservation of the choroidal vessels. Their caliber is unaltered and the walls appear unchanged, the outlines being particularly well defined. The pigment of the choroid is also prominent, but is uniformly distributed through the fundus located between the blood-vessels. In cases uncomplicated by choroidal disease or hemorrhages there are no white patches of scleral tissue present, nor are there any great aggregations of pigment. The affection is slow in onset and course and tends toward incurable blindness.

Gyrate Atrophy of the Retina.—This is a clinical variety of retinitæ pigmentation described by Fuchs. It is very rare, and occurs nearly always in children. Consanguinity of parentage is ascribed as its cause. Night-blindness and contraction of the visual field are the only symptoms.

The ophthalmoscopic appearances are particularly character-

istic. The disk is atrophied and its vessels narrowed. White atrophic dots form around it, increasing in number, and becoming gradually larger until they coalesce and form a broad white girdle, the edge of which is scalloped, completely surrounding the nerve head, but separated from it by a zone of normally colored fundus. The affection is closely related to retinitis pigmentosa, but has associated with it an extensive atrophy of the choroid.

DETACHMENT OF THE RETINA

SYNONYMS: *Ablatio retinæ; Amotio retinæ; Coarctation of the retina.*

This condition, as the name implies, is characterized by a separation of the retina from the choroid. Normally, the retina is attached to the choroid only at the optic nerve and ora serrata, being kept in place by the pressure of the vitreous. Detachment of the retina is therefore only possible when a force acting behind the retina is greater than the pressure of the vitreous; or when, as a result of disease of the vitreous, its pressure is diminished to such an extent that it becomes negative, or, in other words, exerts traction on the retina.

Etiology.—It has been shown by Leber and Nordenson that some cases of detachment are due to the traction of the shrinking vitreous, which tears the retina and permits some of the fluid contained in the space formerly occupied by the vitreous to find its way behind the retina and assist in the mechanism of detachment.

Effusions of blood or serum or tumors between the choroid and retina frequently give rise to this condition. High myopia with posterior staphyloma and ocular traumatism are common causes. In some cases the condition arises idiopathically.

Retinal detachment occurs with greater frequency in men than in women, and attacks by preference individuals of advanced years. One eye alone is usually affected, but occasionally the detachment is observed in both eyes. In these cases the condition is of longer duration in one eye than in the other.

Symptoms.—There is loss of vision corresponding to the area of detachment, which is usually below the horizontal meridian of the eye, although it may have originated in some other portion. Objects in the upper portion of the field are therefore not seen.

Among the early symptoms may be mentioned flashes of light

and apparent distortion of objects. The patient also complains of the appearance of a dark cloud before the eye. Involvement of the macular region renders the eye entirely blind.

Ophthalmoscopic Appearances.—The appearance of the fundus varies according to the character and extent of the detachment. Ordinarily, with the ophthalmoscope at a distance, the fundus reflex will be found not entirely red, but made up of a red and a bluish gray or white portion. The latter is irregular and made up of folds, and changes its position with the movements of the eye, so that at times the red reflex is completely obscured. In less marked cases it is necessary to bring the instrument closer to the eye to detect the condition. The detached portion will appear as an opaque gray membrane which may wave freely in the surrounding fluid. In flat detachments, such as are caused by a growth behind the retina, the membrane is but slightly altered, and the condition can be detected only by the elevation at this point. The amount of the elevation may be determined by comparing the refraction of a blood-vessel on the summit of the detachment with that of the intact retina adjoining it. The blood-vessels appear smaller and are dark and tortuous. The presence of vitreous opacities may obscure the view of the fundus, in some cases necessitating careful taking of the visual field to determine the intact portions of the retina. In extensive separation the characteristic appearance is most marked near the periphery. In the early stages it may be detected anywhere in the eye-ground, but as the case progresses it sinks, and is usually found below the disk. When the separation becomes complete, or nearly so, the detached retina often assumes a funnel-shape, the apex being the papilla and the base the ora serrata, in which case the diagnosis may be made very easily by oblique illumination or even by the unaided eye. The detached portion appears as a number of bluish gray or greenish folds with white tops which project into the vitreous and possess considerable movement; the blood-vessels can be seen coursing over these folds and often becoming hidden in the retinal wrinkles. The tension is always low and the anterior chamber is deeper than normal, but externally the eye appears unaltered.

Diagnosis.—Sudden impairment of vision in one eye, affecting only a portion of the visual field, should always suggest this affection. If the detachment be in its incipiency, it may not have lost

its red reflex, and the condition may escape the examiner's attention. Unless there is a distinct folding or floating of the affected area, it should usually be regarded as a swelling rather than a detachment.

Treatment.—The patient should be placed in a recumbent position with the eyes at absolute rest. The hot pack and pilocarpin by increasing absorption have been advantageously administered; potassium iodid and salicylate of strontium in moderate doses, long continued, have also proved of benefit. If these measures are found to be valueless, puncture of the sclerotic beneath the curtain and the withdrawal of the subretinal fluid should be performed. The author's procedure is similar to that of A. Maitland Ramsay, whose valuable statistics should be consulted (*Transactions of the Ophthalmological Society of the United Kingdom*, vol. xxvi, 1906, p. 79). An iridectomy, together with the use of eserin, has also been advocated. B. L. Millikin reports a case of macular detachment of the retina with reattachment and recovery without treatment. The subconjunctival injection of saline solutions of varying strengths has been attended by temporary relief and deserves a thorough trial. Henri Dor, of Lyons, advises free cauterization of the sclera (avoiding perforation of the eyeball with the cautery) together with subconjunctival injection of sterile sodium chlorid solutions, of from 20 to 30 per cent in strength. The fact that new procedures for the control of this condition are constantly being brought forward is in itself sufficient proof that a satisfactory form of treatment has not yet been devised.

Prognosis.—This is very unfavorable and should be guarded. O. Schwarz, of Leipzig, reports a case eight years after injury. The younger the patient the better the prognosis. In cases due to disease of the vitreous, while detachment may be arrested, there is almost certain to be a recurrence of the condition, since no treatment has as yet been found to successfully combat this causal disease. Paralysis of accommodation due to injury of the ciliary body has followed (Schmidt). There is a better chance to preserve the integrity of the eyeball in idiopathic cases, even though sight cannot be saved. Spontaneous cure is an occasional termination. Such a case recently came under the author's observation at the Medico-Chirurgical Hospital.

TUMORS OF THE RETINA

Glioma.—Glioma, or, as it is sometimes termed, gliosarcoma (Virchow), the latter authority believing that the tumor originated from the glia, or neuroepithelioma (Wintersteiner), is the only malignant growth encountered in the retina. The first case was reported by Hayes in 1767 (Parsons). It always begins in childhood, and is occasionally congenital. Most cases begin before the third year. One eye alone is usually involved, but the affection may be bilateral.

The tumor is regarded by some authorities as an endothelioma of the retina. Its cells are of various sizes and shapes, some of which resemble ganglion cells, while others are more cylindrical, representing the layer of rods and cones. They are arranged in long tubes and surround the blood-vessels. It takes its origin from one of the granular layers of the retina and rapidly increases in size. The terms *glioma endophytum* (Hirschberg and Iwanoff) and *glioma exophytum* (Hirschberg) have been applied according to the retinal origin of the growth. In its progress it may project inward into the vitreous or it may advance outward or backward, causing retinal separation. After its intra-ocular growth it causes secondary glaucoma, rupture of the globe, and finally extra-ocular extension with metastasis, a not uncommon sequence in the case of other intra-ocular tumors. Death may ensue from cerebral involvement, cachexia, intracranial pressure, pyemia, or asphyxia from extension of the tumor. The literature has been well compiled by Parsons and Christian R. Holmes, of Cincinnati.

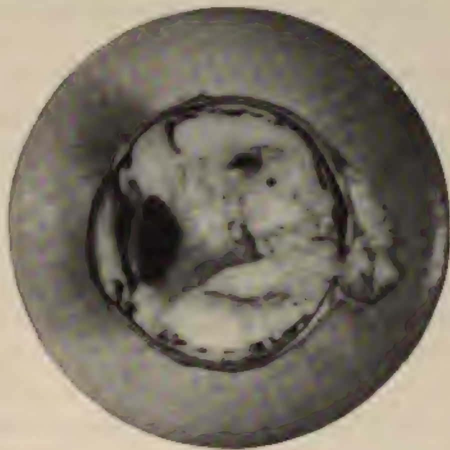


FIG. 113.—GLIOMA OF RETINA. (Author's case.)

Symptoms.—Blindness is the earliest symptom, but it is passed unnoticed by the parents on account of the age of the child. At-

each of which possesses a point of vascularity; the nerve is swollen and apparently involved by the growth.

Microscopic Appearance.—Cornea is normal; anterior chamber is filled with homogeneous exudate; the iris is crowded forward into the angle, obliterating it at the nasal side; the iris shows evidences of old inflammation, is united to the cornea, and is atrophic; the ciliary bodies are atrophic and infiltrated by glioma cells; the processes are lengthened apparently by traction; on the temporal side only four processes remain, and these are drawn into points, each of which is covered by a layer of columnar cells of the pars ciliaris; the pigment forms a narrow base line, and about half of the stroma remains; the lens is healthy; posterior to the lens is a fine granular exudate which represents the remains of the vitreous. It contains glioma cells, polynuclear leucocytes, and free pigment; the retina is detached forward, and is represented only by a few cells of the nuclear layers, a few degenerated fibers of the fiber layer, and a thickened internal limiting membrane that takes the nuclear stain deeply; a few blood-vessels with degenerated walls may also be observed; on the nasal side these changes in the retina are more pronounced; posterior to the retina the growth is found in various stages of retrograde metamorphosis; blood-vessels and blood spaces containing blood and glioma cells are found throughout the tumor, the interfascicular interspaces of the sclera are open; the choroid is atrophic anteriorly, and is invaded by the glioma posteriorly; the nerve fibers are entirely atrophied and almost completely replaced by cells of the growth; the growth is very vascular and the processes of the cells are arranged around the blood-vessels in the form of the so-called perivascular rosettes; the lymph spaces are infiltrated and the perineural vessels contain the characteristic glioma cells.

The patient was again brought to me July 28, 1903, with recurrence of the growth. Puffiness of the lids was noticed two weeks previously, and was temporarily reduced by hot compresses. The recurrent growth is now about the size of an orange. There is also slight systemic disturbance.

Diagnosis.—A somewhat similar reflex is produced by the presence of a purulent exudate in the vitreous. This condition is known as *pseudoglioma*, and may be mistaken for glioma. The latter may be distinguished from the former by its rounded

lobules, the presence of very small vessels on its surface, increase of ocular tension, the history, and the subsequent course. In pseudoglioma there is usually a history of previous suppurative choroiditis, or retinitis, together with lowered tension and the presence of a white reflex from the fundus.

Treatment.—The only hope for saving the patient's life is to enucleate the eyeball, removing as much of the optic nerve as possible. It, of course, goes without saying that early operation increases the chances of saving life. The severed nerve should be examined microscopically, in order to determine whether the growth has extended beyond the point of section. If it is found that the malignant growth has extended beyond this point, glioma of the brain is to be feared, and the prognosis is extremely grave. The tissues of the orbital cavity must be removed, if they have become involved, and any suspicious spots in the walls of the orbit treated with zinc chlorid or the cautery.

Prognosis.—This depends upon the character and location of the growth. If it be extending to the vitreous alone, enucleation of the eye will probably effect a permanent cure; if, however, the orbital tissues have been invaded, a recurrence is very likely to follow; if it is found that the tumor has extended beyond the orbital cavity, a lethal termination is certain, although operation may be performed to alleviate the pain. Recurrence in the other eye takes place in about 18 per cent of all cases. In ten cases, eight died within a year after the tumor was discovered.

In pseudoglioma the prognosis depends upon the irritability of the cyclitis; as a rule, the eye remains quiet for years, then suddenly develops a cyclitis or choroiditis. It must be enucleated early. This condition is the result of a plastic cyclitis, and therefore it is liable to recur.

Cysticercus.—This very rare affection has been observed almost exclusively in Germany, in parts of which pork is eaten raw; it is of even rarer occurrence in this country. Würdeman, of Seattle, and Love, of Philadelphia, each report a case. The cysticercus of the tænia solium may locate itself between the retina and choroid, where it can be recognized with the ophthalmoscope as a sharply defined, bluish-white body, with a yellowish margin. The cyst, which may be clear or purulent, presents a bright spot which corresponds to the head of the cysticercus.

The parasite may move about, giving rise to considerable detachment of the retina, or may become encapsulated behind the retina; or it may burst into the vitreous, and finally, chronic iridocyclitis, with a total loss of sight and phthisis bulbi, is apt to ensue. In Pilgrim's case the parasite invaded a posterior ciliary vessel.

Treatment.—The only hope of saving the eye is by removal of the cyst; this can only be accomplished when it is favorably situated—i. e., when it is close to the equator of the eyeball. The author witnessed an operation for the removal of cysticercus in Vienna, but never in this country.

Prognosis.—The outlook is not favorable.

CHAPTER XII

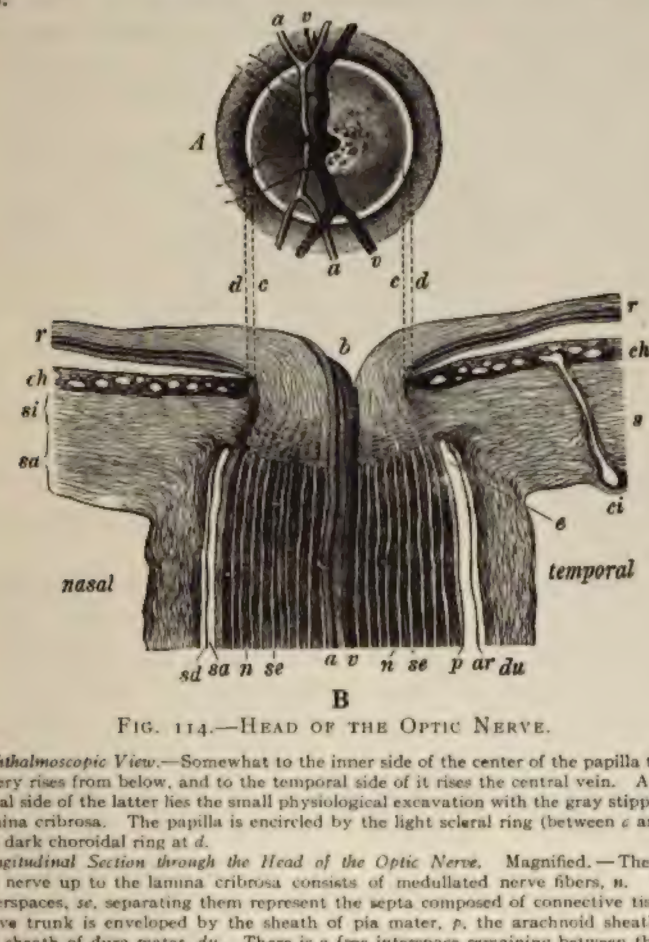
DISEASES OF THE OPTIC NERVE

GENERAL CONSIDERATIONS

THE description of the optic nerve, as ordinarily given, traces its fibers only as far back as the "optic chiasm" or "commissure," after which the bundles of nerve fibers constitute the optic tract, and are described under that name. The optic nerve proper may be divided into three distinct portions: (1) The intra-ocular portion, which expands into the retina; (2) the orbital portion, extending from the globe of the eye to the optic foramen; and (3) the intracranial portion, which lies between the optic foramen and the optic chiasm (see Plate II). It is important to consider these portions in morbid processes, each being accompanied by separate and distinct symptoms.

The point at which the optic nerve pierces the fibrous and vascular tunics to become the intra-ocular portion is situated a little to the inner side of the posterior pole of the globe. The sheaths of the nerve correspond to and are continuous with the membranes of the brain, becoming fused with the outer layers of the sclera as the nerve enters the eyeball. The inner layers of the sclera span the opening for the nerve and form a sievelike arrangement known as the *lamina cribrosa*, through which the various bundles of the nerve pass. A central opening larger than the rest transmits the central artery and vein of the retina, and is known as the "*porus opticus*." As the fibers of the nerve pass through this cribriform arrangement of the sclera they lose their medullary sheaths and become transparent. Occasionally under normal conditions this does not occur, and the medullated nerve fibers are continued into the retina, forming opaque masses near the optic disk when viewed through the ophthalmoscope. (See Fig. 118.) As the fibers of the nerve separate from each other at different levels before expanding into the retina, a funnel-shaped

depression in the center of the disk results, termed the "physiologic excavation." (See Fig. 231.) The terminations of the optic nerve in the retina are the neurons which are contained in the ganglion cell layer in close contact with the layer of rods and cones.



B

FIG. 114.—HEAD OF THE OPTIC NERVE.

A. *Ophthalmoscopic View.*—Somewhat to the inner side of the center of the papilla the central artery rises from below, and to the temporal side of it rises the central vein. At the temporal side of the latter lies the small physiological excavation with the gray stippling of the lamina cribrosa. The papilla is encircled by the light scleral ring (between *c* and *d*), and the dark choroidal ring at *d*.

B. *Longitudinal Section through the Head of the Optic Nerve.* Magnified.—The trunk of the nerve up to the lamina cribrosa consists of medullated nerve fibers, *n*. The clear interspaces, *se*, separating them represent the septa composed of connective tissue. The nerve trunk is enveloped by the sheath of pia mater, *p*, the arachnoid sheath, *ar*, and the sheath of dura mater, *du*. There is a free interspace remaining between the sheaths, consisting of the subdural space, *sd*, and the subarachnoid space, *sa*. Both spaces have a blind ending in the sclera at *e*. The sheath of dura mater passes into the external layers, *so*, of the sclera, the sheath of pia mater into the internal layers, *si*, which latter extend as the lamina cribrosa transversely through the optic nerve. The nerve is represented in front of the lamina as of light color, because here it consists of nonmedullated and hence transparent nerve fibers. The optic nerve spreads out upon the retina, *r*, in such a way that in its center there is produced a funnel-shaped depression, the vascular funnel, *b*, on whose inner wall the central artery, *a*, and the central vein, *v*, ascend. The choroid, *ch*, shows a transverse section of its numerous blood-vessels, and toward the retina a dark line, the pigment epithelium; next the margin of the foramen for the optic nerve and corresponding to the situation of the choroidal ring, the choroid is more darkly pigmented. *ci* is a posterior short ciliary artery which reaches the choroid through the sclera.

The orbital portion of the nerve is more or less folded upon itself, or S-shaped, to allow free movement of the eyeball in all directions without tension upon the nerve. The nerve is composed of bundles of medullated fibers, supported by a network of fibrous tissue, between which are lymphoid spaces. The membranes or sheaths of the nerve are three in number, and from without inward are: the dural, arachnoid, and pial sheaths. The lymph spaces common to these membranes, when surrounding the brain, are also present in this situation, and communicate with the more minute spaces in the nerve itself. The lymph space between the dural and pial sheath is known as the intervaginal space, and is divided into two portions by the arachnoid sheath. Anteriorly this space terminates blindly, where the sclera and nerve sheaths unite, and posteriorly it is continuous with similar lymph spaces between the meninges of the brain. A short distance behind the globe of the eye the optic nerve is pierced by the central artery and vein of the retina. The intracranial portion is that which extends from the optic foramen to the commissure. It has the same sheaths and lymph spaces, and is liable to considerable compression by the bony wall of the orbit in the event of its becoming the seat of inflammation.

The optic nerves now meet and cross each other, forming the optic chiasm or commissure, through which the fibers may be traced to the optic tract of the opposite side, and from thence to their central origin. In order to obtain a clear conception of the relation of the chiasm to the various pathological conditions of the optic nerve, it is necessary to follow the course of the optic tract from its origin in the brain, until, by its union with the tract of the opposite side, the chiasm is formed.

The optic tracts may be traced to various nuclei in the cerebral cortex in the neighborhood of the mesial surface of the occipital lobe, the cuneus, and the region of the calcarine fissure. Each optic tract is divided into two bands shortly after its origin in the brain. One of these arises from the stratum opticum of the corpora quadrigemina and emerges from the nates of this body as the anterior brachium. It then passes obliquely outward between the inner and outer geniculate bodies. The second band takes its origin from the optic thalamus, and after passing through the inner geniculate body, from which it derives some fibers, joins

with the first band. The result of this union is a flat band which passes obliquely across the under surface of the crus cerebri, to the anterior margin of which it becomes attached. The shape of the tract is now altered, becoming more cylindrical in character. It then passes forward, being reënforced by fibers from the tuber cinereum and the lamina cinerea.

The tracts from either side now advance toward each other and cross, forming the optic commissure, a quadrilateral body,

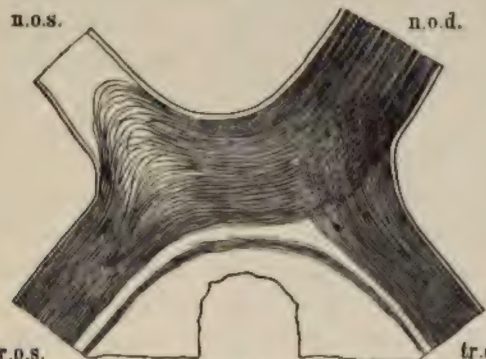


Fig. 115.—Chiasm in Atrophy of the Left Optic Nerve. Magnified 3 × 1.

The specimen is from a man, sixty-five years of age, whose left eye had been blind from childhood because of a total staphyloma of the cornea, due probably to blennorrhœa neonatorum. The cut represents a section passing through the chiasm in the horizontal plane, and stained with hematoxylin by Weigert's method, so that the normal (medullated) nerve fibers look black, while the atrophic fibers are unstained. The left optic nerve, *n.o.s.*, is completely atrophic, being both unstained and also considerably narrower than the right, *n.o.d.* The greater number of the fibers composing the latter pass transversely through the chiasm into the left optic tract, *tr.o.s.* On their way they make a looplike bend into the left optic nerve. The smaller portion of the fibers of the right optic nerve remain on the right side of the chiasm, and pass over into the right optic tract, *tr.o.d.* Since the nondecussating fibers are less numerous than the decussating, the right track appears somewhat narrower in cross-section than the left. The bundle of nerve fibers running in a curve along the posterior border of the chiasm, and separated from it by a light-colored zone, is Gudden's commissure (or commissura inferior), which contains no optic-nerve fibers. (See Plate II.)

which rests upon the optic groove of the sphenoid bone. Partial decussation of the fibers then takes place—the fibers on the inner margin being continued from one side of the brain to the other, having no connection with the optic nerves, the fibers on the outer margin are continued on into the optic nerve of the same side, and the central fibers cross, so that fibers from one optic tract may be traced into the optic nerve of the opposite side. In the anterior portion of the chiasm a few fibers serve to connect the optic nerves alone, having no connection with the optic tracts at all. Bern-

heimer has demonstrated anatomically the existence of uncrossed optic nerve fibers in man by the microscopic examination of twenty sections through the chiasm of a child with bilateral microphthalmos. This confutes Kölliker's statement that the centripetal fibers arising from the retina in man, dog, cat, and rabbit cross completely.

From the arrangement of the fibers in the commissure it may be easily seen that the left half of each visual field is controlled by the right optic tract and centers of the right side, and that the right half of each visual field receives its innervation from the left optic tract and corresponding cerebral centers. To avoid confusion, it may be here stated that the right half of the visual field corresponds to the left half of the retina of each eye, and *vice versa*.

The "macula lutea" is not bisected by this arrangement, as would be supposed, as it is supplied by fibers from each optic tract. Bearing the knowledge of the partial decussation of the fibers in mind, the character of any existing blindness, and the situation of its cause, may be easily ascertained. For instance, monocular blindness arising from a lesion of the nerve is due to some morbid process situated anterior to the optic commissure; blindness limited to corresponding sides of the visual field (homonymous hemianopsia) results from disease of the optic tract or central nuclei on the side opposite to that of the blindness; blindness limited to the macular region (central scotoma) is due to some pathological process in the bundle of nerve fibers supplying the macula lutea; blindness on both temporal or nasal sides of the visual field (bitemporal or binasal hemianopsia) finds its cause in disease of the chiasm.

The reaction of the pupils, when light is thrown upon the various parts of the retina, is also of great importance in this connection. If one tract alone is affected the pupils respond to light thrown upon the intact portions of the retina, but fail to do so when the light is directed toward the blind areas (Wernicke's pupillary reaction sign). In such cases the situation of the lesion is below the corpora quadrigemina. Response of the pupils to light thrown upon both sides of the retina in cases of blindness indicates that the lesion is situated higher up in the course of the tracts than the corpora quadrigemina.

As the function of the optic nerve is to conduct impulses from the retina to the brain that result in vision, any disease or injury of that structure will result in impairment of vision and the visual field. The visual field is the extent or space through which it is possible to discern objects when the line of vision is directed toward one point. Each eye has a field of vision peculiar to itself, but when both eyes are combined the visual fields overlap and form a common field of vision. Vision may be divided into peripheral and central. All acute vision is central and is performed by the macula lutea alone. A diminution in the acuity of vision occurs as the periphery is reached, at which point it is merely protective in character. The area of the visual field may be determined roughly by bringing the hand in from infinite distance in all meridians until it is perceived; but a more accurate method of obtaining the same result is by means of the perimeter.

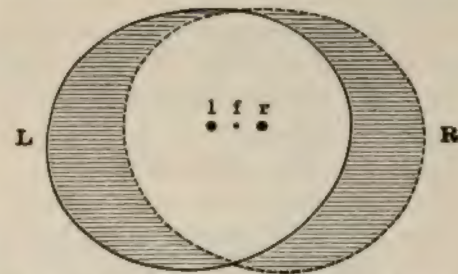


FIG. 116.—BINOCULAR FIELD OF VISION. (After Möser.)

The undotted line, *L*, bounds the visual field of the left eye, the dotted line, *R*, the visual field of the right. The median portion of the two visual fields overlap to an extent shown by the surface left white. This is, accordingly, the binocular field of vision, all objects in which are seen by both eyes at the same time. In its center lies the point of fixation, *f*, and at either side of the latter the blind spots, *r* and *l*, of the right and left eye. Adjoining either side of the binocular field of vision are the temporal divisions of the two visual fields (the shaded areas in the figure), objects in which are seen with one eye alone.

The perimeter is an instrument provided with an arm which represents a portion of the arc of a circle. This arc is graded in degrees and can be rotated, its central portion being marked by a white spot which corresponds to the fixation point. A small square or circle containing colored pieces of paper varying in size from 5 to 10 mm., so arranged that only one piece is visible at a time, is made to travel on the arm from the extreme periphery toward the center until perceived through all the meridians. The degree in each meridian at which the traveling object is perceived is noted upon a chart especially provided for this purpose. The patient's chin should be placed upon a rest situated about 12 inches from the fixation point, and each eye should be tested

separately. The field for white should be first ascertained, and normally this extends about 95 degrees to the temporal side, 60 degrees upward, 50 degrees inward, and 80 degrees downward, being influenced greatly by the extent of the bony processes of the face. The fields for blue, red, and green follow the white field in this order, each being more contracted than its predecessor.

A blind spot extending over 5 degrees is detected when each eye is tested separately, about 15 degrees to the temporal side of the fixation point, and corresponds to the entrance of the optic nerve. In the combined field these are effaced as a result of the overlapping of the individual fields.

Campimetry is sometimes employed in cases of extremely low vision. A blackboard is marked off in degrees and a lighted can-

FIG. 117.—MCHARDY SELF-RECORDING PERIMETER.

dle is placed at the fixation point. A second lighted candle is then brought in from the periphery, through all the meridians, and the point at which it is perceived is marked on the board. The light sense is determined also by this test.

Blind spots that occur in the visual field as the result of disease of the nerve are known as scotomata. They may be *positive* when the patient is conscious of their presence by the black spots in the

visual field, or they may be *negative* when they can be detected only by the perimeter. Scotomas may also be *relative* when the perception of light is diminished or *absolute* when there is a corresponding complete loss of vision. According to their situation they may be *central*, *paracentral*, or *disseminated*, and according to their size they may be *large*, *small*, and *irregular*.

ANOMALOUS CONDITIONS OF THE OPTIC NERVE

Perhaps the most frequent anomaly is that already referred to as *opaque nerve fibers*. They may be present in one or both eyes, and appear as a dull white or bluish patch at the upper or

FIG. 118.—OPAQUE NERVE FIBERS. (Author's case.)

lower margins of the disk, terminating in radiations into the retina. This condition should not be mistaken for atrophy of the retina or an area of fatty degeneration, or the " snow-bank " appearance of albuminuric retinitis. It is seldom found at the

nasal or temporal side of the optic-nerve head, and occasions disturbance of vision, with the exception of an increase in t extent of the blind spot. (See Retina.)

Coloboma of the disk consists in a failure of the two segmen of the optic nerve to properly unite in the latter months of em

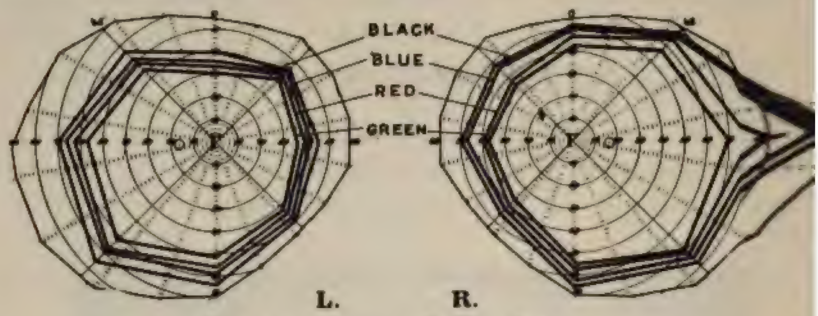


Fig. 119.—Normal Visual Fields.

bryonal life, and is usually a part of a general coloboma involvin the iris, retina, and choroid, but may exist alone. (See Colo boma of the Choroid.) Its presence causes an enlargement in the appearance of the head of the optic nerve, and an excavation ex-tending downward and backward may be discerned. The pig-ment at the nerve borders is unusually excessive in amount, and

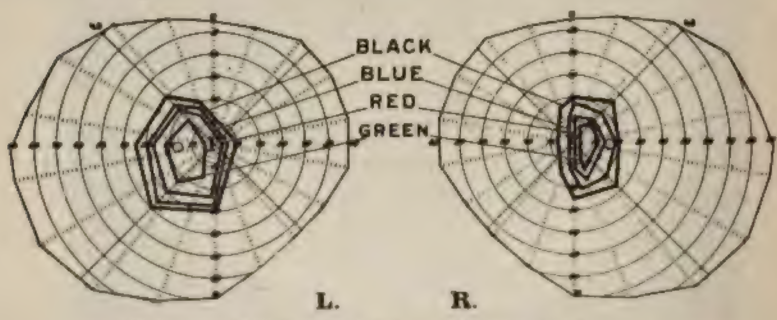


Fig. 120.—Visual Fields in Glaucoma Simplex.

the depth of the excavation causes an apparent distortion and uneven division of the retinal vessels. The most rare anomaly of the optic nerve is its complete absence. Spiller ("Brain," 1902, p. 631) has observed a case in which the eyeballs, optic foramina, optic nerves, chiasm, optic tracts, and external geniculate body

The principal pathological conditions to which the optic nerve is liable are congestion, anemia, inflammation, atrophy, and neoplasms.

Congestion of the optic disk accompanies many abnormal conditions of the eye, the principal of which are probably errors of refraction, particularly hypermetropia. It precedes true inflammation of the nerve, and is associated with inflammation of adja-

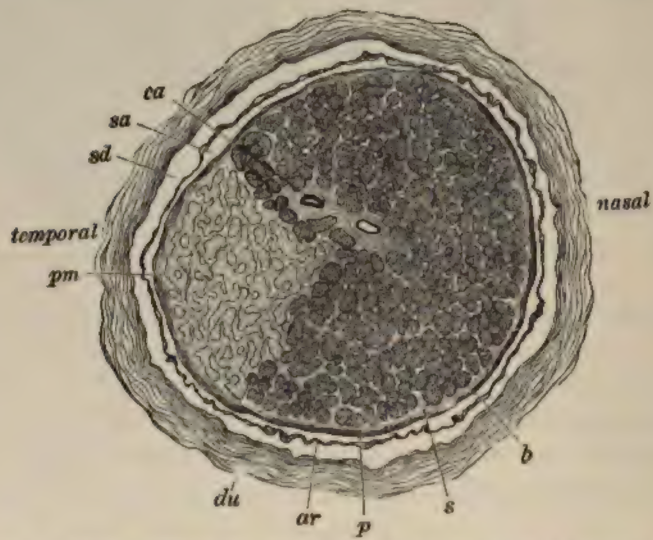


FIG. 123.—CROSS SECTION OF THE OPTIC NERVE, WITH ATROPHY OF THE PAPILLO-MACULAR BUNDLE (SECTION MADE 4 MM. BEHIND THE EYEBALL). Magnified 15 × 1.

The optic nerve is enveloped in the dural sheath, *du*, the arachnoid sheath, *ar*, and the pia sheath, *p*. Between the first and second is found the subdural space, *sd*; between the second and third, the subarachnoid space, *sa*. On the outer and upper side of the center of the section is seen the central artery, *ca*; and more centrally is seen the central vein. These are surrounded by the cross sections of the nerve bundles, *b*, which are separated from each other by the septa, *s*, of connective tissue. At the temporal side, a wedge-shaped segment, *pm*, is distinguished from the rest of the cross section of the nerve by its paler color. This represents the atrophic papillo-macular bundle. Within the confines of it the cross sections of the nerve bundles are narrower and the septa o. connective tissue are correspondingly broader.

cent structures of the eye, as syphilitic iritis or corneal ulcer (Lang). It may also arise from a general plethoric condition of the body, cerebral congestion, and conditions of the thoracic and abdominal viscera that induce disturbances of the peripheral circulation. Prolonged exposure to intense heat accompanied by glare are also etiologic factors. It is manifested by increased red-

ness of a brick-dust hue, blurring of the margins of the disk, and fullness of the veins. On account of its resemblance to optic neuritis it has been termed "spurious optic neuritis." The treatment consists of constitutional measures if there be a general cause. The free use of saline purgatives is always of value. The correction of any ametropia present usually suffices to relieve the condition.

Anemia of the optic-nerve head is less frequent than the opposite condition and is less often recognized. Although present in all forms of anemia and chlorosis, it is most marked in obstruction of the local circulation by the presence of an embolus in the central retinal artery. The treatment in such cases is of very little avail.

INFLAMMATION OF THE OPTIC NERVE

Inflammation of the optic nerve, or optic neuritis, may be situated in the head of the nerve, constituting *papillitis* or *intra-ocular optic neuritis*, or it may be posterior to the globe, to which condition the term *retrobulbar neuritis* is applied. The term choked disk, or papilledema, as the result of recent experiments, now occupies a distinct position, although there is still some obscurity in the pathology.

PAPILLITIS

SYNONYMS: *Intra-ocular Optic Neuritis; Choked Disk, Papilledema (Elschnig).*

Definition.—An affection of the optic nerve characterized by pathological changes confined to the head of the nerve (*intra-ocular optic neuritis*), causing a condition known as choked disk, when the swelling assumes a pronounced character (Parsons) ophthalmoscopically. Both in papillitis and choked disk there is an edematous swelling. In papillitis there is infiltration of the products of true inflammation.

Etiology.—The principal causes may be divided into *intracranial* and *constitutional*, the first often depending on the second. The most frequent cause is *brain tumor*, of which choked disk (*Stauungspapille*) is often the first distinctive symptom, according to Gowers existing in *four fifths* of all cases of cerebral tumors. The causes of choked disk are discussed in the chapter on "Nervous Diseases" (*q. v.*). The other symptoms, such

as headache, vertigo, vomiting without nausea, pressure symptoms, and psychic disturbances, serve to confirm the diagnosis in such a case. Although choked disk nearly always points to brain tumor, it by no means serves to localize it, although it occurs more frequently in tumors of the base of the brain. In some cases the changes in the macular region suggest the possibility of albuminuric retinitis. Conditions of the brain other than tumors, such as meningitis, particularly of the tubercular variety, abscess, and hydrocephalus, may also induce optic neuritis. In rare instances choked disk may occur in aneurysm of the cerebral arteries. A series of cases have been reported by St. Clair Thompson in which a persistent discharge from the nose of a fluid resembling cerebrospinal fluid was associated with optic neuritis. The symptoms of cerebral pressure were present, and in all probability these were cases of internal hydrocephalus, the fluid finding its way from the third ventricle through the cribriform plate of the ethmoid bone to the nose. Disease of the orbital structures, such as tumors, caries, or adjacent periostitis, as in the case of the nasal sinuses and the antrum of Highmore, are often responsible. Paresis, locomotor ataxia, and multiple sclerosis are often associated with optic neuritis. C. O. Hawthorne has observed a case of double optic neuritis in a chlorotic patient directly traceable to intracranial thrombosis.

The *constitutional affections* of etiological significance in this connection are syphilis and tuberculosis, particularly those manifestations that occur within the cranium. Among the less frequent causes may be mentioned measles, scarlet fever, diphtheria, influenza (infectious optic neuritis (Uhthoff)), rheumatism, nephritis, arteriosclerosis, toxic irritants, like lead and alcohol, anemia caused by menstrual disturbances, lactation, or pregnancy (Kipp), sunstroke, fracture of the skull, and exposure to cold. It is occasionally congenital, and may arise without obvious cause.

Most cases are bilateral in character, but unilateral papillitis may follow inflammatory conditions or injury of the orbit or adjacent sinuses, such as disease of the sphenoid, ethmoid, frontal, or maxillary sinus, tumors of the orbit or the nerve itself, and panophthalmitis. Unilateral choked disk has, however, been observed in several well-attested cases of cerebral tumor (Gowers, Hughlings Jackson, Field, Ulrich, and others).

Varieties.—Two clinical varieties have been described—choked disk and descending optic neuritis. Choked disk is distinguished by marked swelling and enlargement of the disk alone with considerable engorgement of the veins without decided inflamma-

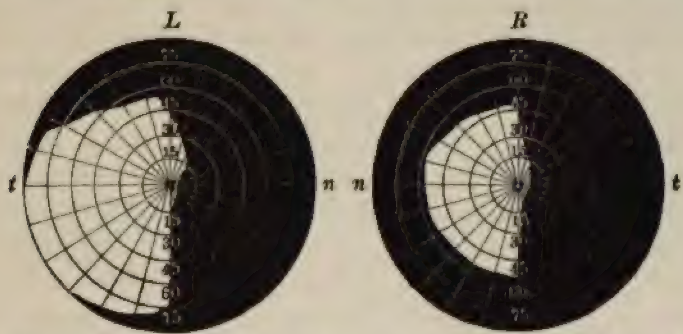


FIG. 124.—HOMONYMOUS HEMIANOPSIA. (After Schweigger.)

The areas which have been left white correspond to the left halves of the visual fields, *R* and *L*, of the right and left eye, which are still intact: *t*, temporal; *n*, nasal side.

tion, while descending optic neuritis is characterized by more inflammatory exudation and extension into the surrounding retina, has swelling of the disk and changes in the blood-vessels. Parsons applies the term "papilledema" (Elschnig) to replace

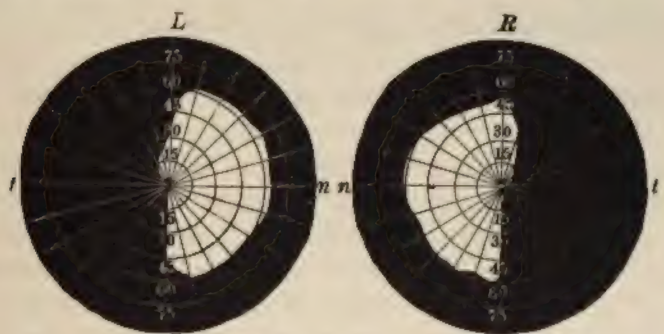


FIG. 125.—BITEMPORAL HEMIANOPSIA. (After Schweigger.)

The areas left white correspond to the nasal halves of the visual fields, *R* and *L*, of the right and left eye, which are still intact: *t*, temporal; *n*, nasal side.

choked disk when speaking of a swelling of more than 2 D. associated with intracranial pressure. It is often difficult to separate these varieties on account of the great frequency of transitional forms. A combination of retinitis and papillitis is not

uncommon and constitutes neuroretinitis. As regards duration, papillitis may be acute or chronic, the latter being most common.

Symptoms.—Vision usually undergoes marked alterations, depending upon the severity of the inflammation, but occasionally it is unaffected. Blindness may, however, occur. The visual field is considerably contracted, particularly at the periphery. The contraction for color is especially well marked, and the blind spot is larger than normal. Hemiopia and scotomata may be present, but at no time is pain a symptom of optic neuritis. There are no external manifestations, unless blindness be complete, in which case the pupil does not usually react. It seems established, however, that the pupil can react in spite of complete blindness if the lesion is posterior to the corpora quadrigemina or the visual centers themselves are involved, the pupillary reflex arc remaining preserved. The reaction of the pupil to light may be present in complete blindness due to disease of the optic nerve itself (Wilbrand and Saenger, quoted in Fuchs (translated by Duane), page 307). Duane (*loc. cit.*) has seen one such case. It is hypothetically explained in this case that the fibers conducting the light reflex are more resistant than those conveying the visual impressions.

Ophthalmoscopic Appearances.—The head of the optic nerve seems swollen and appears to project forward. The term "woolly," used in this connection, is most descriptive. It is larger than normal and of a whitish or grayish color, and often marked by striæ upon its surface. The normal striation at the edge of the disk is considerably exaggerated. The optic nerve may be so swollen and translucent that Marcus Gunn's description of "juicy" can be applied. Hemorrhages and white spots upon the disk are not uncommon. The margins of the nerve are considerably blurred, so that no definition of outline is present, the location of the nerve being determined by the convergence of the retinal blood-vessels, which seem to come forward as they leave the disk. The physiological cup is obliterated. The veins are greatly distended and tortuous, often to a marked degree, and the arteries may be smaller than normal, and seem to suffer interruptions in their course, owing to the swelling of the nerve. The retina in the immediate neighborhood is congested and edema-

tous, and often the site of hemorrhage in various stages of absorption. This appearance is best seen in neuroretinitis.

Pathology.—As in all other inflammations, there is congestion with later permanent dilatation of the blood-vessels and exudation of leucocytes. The incidental swelling takes place in the direction of least resistance, causing distention of the intervaginal

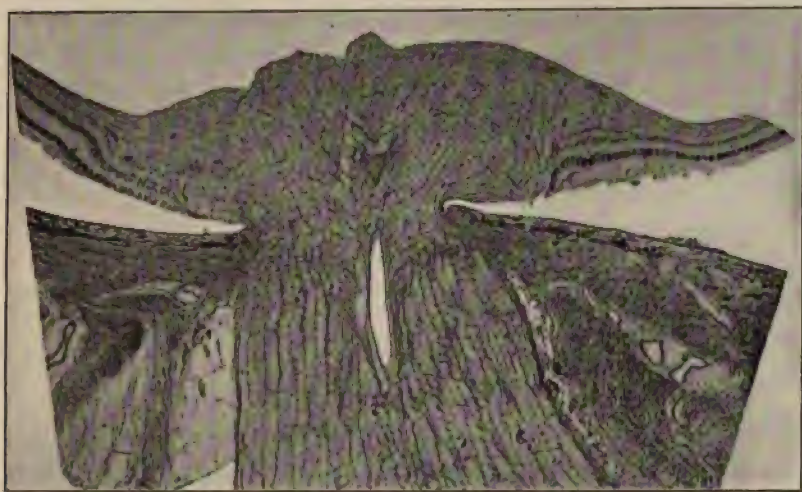


FIG. 126.—CROSS SECTION OF OPTIC NERVE, IN A CASE OF PAPILLEDEMA, DUE TO A GLIOMA OF THE CEREBELLUM. (From Elschnig.)

lymph space and projection forward of the head of the nerve with edema and hemorrhage. As a termination, connective tissue forms which undergoes contraction, giving rise to optic atrophy. The exact manner in which cerebral and other conditions bring about optic neuritis has not been determined. It is probable that in cases due to brain tumors the increased intracranial pressure influences the pressure within the intervaginal lymph space and induces swelling of the optic nerve, while in cases due to meningitis there is an extension of the inflammation by continuity and contiguity of structure. Papillitis, however, does not attend all forms of increased intracranial pressure, as is shown in cerebral hemorrhage and intracranial aneurysm. It has also been maintained that irritating substances in the lymph and blood streams have been brought to the nerve and induce reactionary changes in the form of inflammation. It is most likely

that a combination of these processes is present in all forms of optic neuritis, but in varying proportions, according to the cause. Microörganisms by direct or indirect contact produce the inflammation upon an optic nerve the vitality of which has been reduced by alterations in nutrition.

Diagnosis.—In the early stages papillitis may be confused with conditions resulting from eye-strain, as the prominence of disks occasionally seen in hypermetropia and in the later stages with albuminuric retinitis. The distinguishing features of the disease are its localization to the disk, obscuration of the disk margins, obliteration of the physiologic cup, contraction of the visual fields, and the change in the caliber of the blood-vessels.

The ophthalmoscopic appearances in no way indicate either the precise location or the size of an intracranial growth. Small brain tumors may cause great swelling of the nerve, while larger ones may cause but little. Sir Victor Horsley and Cushing both lay more stress on the signs of beginning atrophy as to the eye longest affected.

Prognosis.—The ultimate outlook for vision is always unfavorable, although perfect vision may be retained for months in marked cases. It depends primarily upon the degree of inflammation, and secondarily upon the extent of the subsequent atrophy of the nerve. Vision is always impaired and may be lost entirely. A fatal termination may occur in those cases of cerebral origin. Recurrences are not uncommon, but seldom take place in cases due to brain affections, when the primary condition has been permanently relieved, as in the removal of syphilitic deposits.

Treatment.—In those cases in which a brain tumor can be definitely localized it should be removed by trephining, after a careful trial with internal medicine. The predominance of syphilitic lesions in the brain would indicate the free administration of mercury and the iodids. In the absence of history or other signs of syphilis benefit often follows the use of such drugs. Other incidental or causal conditions should receive the same treatment as under other circumstances. Dark glasses should be worn, and the patient should abstain from using the eyes as much as possible. In monolateral cases operative measures directed toward the causal disease are necessary, and sometimes enucleation is required.

Operative Treatment.—Over twenty years ago Sir Victor Horsley showed that the release of intracranial pressure arrested and cured optic neuritis. While this has been confirmed since then by numerous observers, the subject has been of late actively revived, due to the estimable work of Spiller, Frazier, De Schweinitz, Bordley, Cushing, Robinson, and others. Horsley's conclusions, which follow, are a good representation of the consensus of opinion, pending further observations: (1) That all cases of optic neuritis should be relieved as soon as possible by operative treatment. (2) That such operative treatment, in the absence of other indications, should be opening of the subdural space in the temporal or subtentorial region. (3) That the physician or surgeon in charge of a case must be held to be responsible for consequent blindness if the neuritis be not treated as soon as detected.

The patient should, if feasible, be given the chance of specific treatment.

RETROBULBAR NEURITIS

(Orbital Optic Neuritis)

Inflammation of the orbital portion of the optic nerve. It may be acute or chronic.

Acute retrobulbar neuritis is an infrequent condition, and is nearly always unilateral in character.

Etiology.—The most important etiological factors are exposure to cold, rheumatism, gout, syphilis, the poisons of diphtheria, scarlet fever, malaria, etc., alcohol and lead intoxication, and the extension of inflammation from adjacent structures. Intestinal parasites may also induce this condition. Disseminated sclerosis and acute myelitis are often associated with it.

Symptoms.—The most prominent manifestation is the rapid and progressive impairment of vision, inducing, not uncommonly, complete or partial blindness in the course of a week. The patient complains of neuralgic pains in the head, face, and eyeball that are intensified by ocular movements. Tenderness may be elicited by pressure upon the globe of the eye. The external appearance of the eye is in no manner altered. Ophthalmoscopic examination shows no distinctive signs, or the borders of the disk may be hazy and the vessels altered in character. Accord-

ing to Dr. A. W. Stirling, the following phenomenon is frequently observed. After the primary contraction of the pupil to light, while the light is still held upon it, the pupil dilates and wavers to a degree more marked than in the normal eye. This reaction, together with the presence of a central scotoma, is sufficient to enable a diagnosis to be made from hysteria. The disease runs an acute course, terminating in one or two months. While at times bilateral, it is more often a unilateral affection. The vision may return to normal or it may remain considerably impaired. The inflammation involves the papillo-macular bundle of fibers in the optic nerve, giving rise to central scotomata and alterations in the visual field. In severe cases the inflammation may extend throughout the diameter of the nerve.

Treatment.—As some form of acute toxemia is the usual cause, free purgation and diaphoresis by pilocarpin or hot baths should be promptly instituted. The salicylates, iodids, mercury, and strychnin are particularly indicated. Efforts should be made to ascertain the exciting cause, and to remove it if possible. Prognosis should be guarded. The affection usually tends to recovery under treatment; in severe cases central vision may remain considerably impaired.

Chronic retrobulbar neuritis is a common affection, and usually attacks both eyes at the same time. (See Toxic Amblyopia.)

Etiology.—The excessive use of alcohol and tobacco for long periods is the most common cause, and the condition is most frequent in middle-aged men. The continued absorption of other poisons, such as iodoform, lead, arsenic, wood alcohol, bisulphid of carbon, stramonium, cannabis indica, chloral, opium, nitrobenzol, and dinitrobenzol, also produce the affection. Diseases, such as diabetes, syphilis, and autoinfection from the intestinal tract, may give rise to this form of optic neuritis. Diseases of the nervous system, such as disseminated sclerosis, may also be attended by it. (The subject will be more fully considered hereafter under the heading of "Toxic Amblyopia.")

Symptoms.—The visual acuity becomes impaired, being best in a dull light or toward evening. The field of vision undergoes no peripheral alteration, but central scotomata, particularly for red and green, are well marked. These scotomata are usually relative, but may be absolute in character. Ophthalmoscopic exami-

nation reveals nothing abnormal in the early stages, but as the condition advances pallor of the disk toward the temporal side will be noticed.

Course and Prognosis.—The course of this affection is very slow and prolonged, increasing proportionately with the continuance of the poison. Gradual but permanent improvement follows the withdrawal of the cause in most cases, but in severe types of the affection diminution of the visual field and central scotomata may persist. The nature of the disease is largely interstitial, limiting itself to the axial fibers of the nerve or those supplying the macular region, thus accounting for the presence of central blind spots.

Treatment.—The withdrawal of the drug causing this condition is the first indication. Stimulation by means of good food, fresh air, outdoor exercise, and drugs, such as strychnin or nux vomica, increased to the physiologic limit, is indispensable. Potassium iodid may be given to assist in the absorption of the products of inflammation. Dark or amethyst-tinted glasses should be worn constantly, and the use of the eyes should be reduced to a minimum. Galvanism or the high-frequency current may stimulate the retina.

TOXIC AMBLYOPIA

Under this heading belong the cases that are due primarily to the presence of poisonous materials in the blood. These materials may be produced within the body, as in uremia, diabetes, and malaria, or they may be introduced from without, as in the case of tobacco, alcohol, lead, etc. In the early stages these poisons merely induce aberration of function, but in advanced stages retrobulbar neuritis (already described) and macular diseases may be demonstrated. In nearly all varieties of this condition there is diminution of central vision, with central scotoma, and different degrees of color-blindness. The principal diseases that give rise to this condition by their toxins are uremia, ptomain poisoning, diabetes, malaria, and whooping cough. The uremic variety is most common during the kidney complication of scarlet fever and pregnancy. Its chief characteristic is the preservation of the pupillary reaction during the period in which vision is suspended. Headaches, nausea, and convulsions are frequently

present. It must, however, be remembered from a standpoint of diagnosis that reflex amblyopia may follow irritation of nerves in more or less close relation to the optic centers, as in diseases of the teeth, intestinal worms, and uterine affections. Diabetic amblyopia is distinguished by its marked tendency toward color scotoma and the constitutional symptoms. The amblyopia of malaria is periodic in character and confirmed by finding the plasmodium malaria in the blood along with the effect of antiperiodic treatment. The poisons introduced from without, either by the mouth, by inhalation, or even by the skin (see Methyl Alcohol), that are potent factors in the production of amblyopia and blindness, are alcohol, tobacco, lead, quarilla, quinin, santonin, arsenic, ergot, salicylic acid, Jamaica ginger, anilin (Veasey) (methyl alcohol substituted for ethyl alcohol as a vehicle for cheap whisky), nitrate of silver (rarely), cannabis indica, iodoform, chloral, potassium chlorate, antipyrin, aspidium, cocain, nitrobenzol, dinitrobenzol, carbon bisulphid, and coffee. The purely functional disturbance of vision is most manifest in the acute poisoning by these drugs.

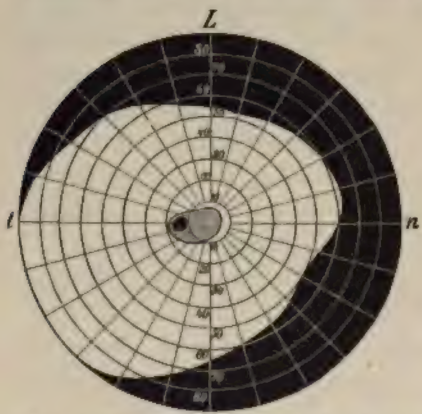


FIG. 127.—FIELD OF VISION OF THE LEFT EYE OF A MAN SUFFERING FROM TOBACCO AMBLYOPIA. (Fuchs.)

The visual field when tested with a white object (shown by the portion left white in the figure) is normal. When, however, the examination is made with a red object, a central scotoma is found having an extent represented by the shaded area which forms an irregular oval. The small black circle comprised in this area represents Mariotte's blind spot.

Tobacco and Ethyl Alcohol.—The amblyopia caused by the conjoint use of tobacco and alcohol will be considered as one subject in as far as the clinical manifestations caused by either one of these substances cannot in the light of our present knowledge be differentiated from the symptoms caused by their combined use. It is also a well-established fact that in the majority of cases we have to deal with a combination of tobacco and alcohol abuse, the latter, as a rule, forming the typical clinical picture, which is more pronounced when the two have been used to excess.

It is well known, however, that either tobacco or alcohol may individually cause toxic amblyopia. This has been shown, not only in cases where only one of the substances was responsible, but in cases where both alcohol and tobacco were used to excess, and the withdrawal of one did not cause improvement until the other also was given up. As Lewin and Guillery pertinently remark, the enormous consumption of tobacco in the Orient seldom if ever causes amblyopia, and only then, as a rule, when combined with alcoholism. Notwithstanding this, the reverse has also been observed, so that the etiological importance of each of the substances by itself has certainly not yet been definitely established.

Pathology.—A number of observers have made anatomical studies of these cases. It is believed as a result of the investigations of Uhthoff and others that the pathological lesion is essentially a *degeneration of the papillo-macular bundle of optic-nerve fibers*, although there are others holding different views (Nuel, Schiek, Birch-Hirschfeld). This bundle of fibers, triangular in shape with its base down and outward, its apex corresponding with the central vessels of the disk, forms that characteristic pale sector of the disk seen in these cases. The lesion then continues through the nerve and along the optic tracts as far as the primary optic centers.

Quinin.—The symptoms of quinin amblyopia differ considerably from those caused by tobacco and alcohol. There is not only amblyopia, but often complete blindness. Instead of the typical scotomata seen in the case of tobacco and alcohol, there may be no scotomata, but only a peripheral contraction of the visual fields. It is essentially an acute intoxication, occurring in many cases where the drug is given for malaria, although it occurs as well when the drug is administered for other purposes. Idiosyncrasy is an important factor. Central and eccentric scotomata have been seen. Paresis of individual muscles and ptosis have also been observed. The chief objective symptom, however, is a pronounced contraction of the retinal blood-vessels associated with pallor of the papillæ (ischemia retinæ). The pupils are markedly dilated, often at maximum, do not contract to light, but occasionally to accommodation and convergence. The affection is usually bilateral. The pathology has been extensively

studied. De Schweinitz found endovasculitis in the optic-nerve vessels of dogs that had been poisoned by quinin, with thrombosis of the central artery, associated with atrophy of the visual tracts. According to Holden there is degeneration of the ganglion cells. It is claimed by De Bono that quinin inhibits the movement of the pigment epithelium and of the rods and cones. Whether the cause of quinin amaurosis takes place through the *vasomotor system* or whether it is due to a *direct toxic effect* of the quinin, has yet to be definitely determined.

Methyl Alcohol.—Wood alcohol, as well as preparations containing it, Columbian spirits, adulterated whiskies, bay rum, Cologne spirits, as well as various methylated essences and extracts, may cause rapid and complete failure of vision associated with severe constitutional symptoms, such as acute gastro-enteritis, nausea, vomiting, delirium, coma, and even death. It not only occurs in those who have become intoxicated by drinking it or substances adulterated with it, but may also occur among painters and those working with shellac who are exposed to the fumes. In the cases of Patillo, Casey Wood, Stricker, Carhart, and Colburn, the poison entered the lungs. In a case of De Schweinitz's the poison entered the lungs and cutaneous surface. The visual fields in these cases are contracted, accompanied by central scotomata, generally absolute. Visual acuity may vary from a marked reduction to complete blindness. The ophthalmoscopical examination may at first show normal eye-grounds, followed later by paleness of the disk, with obscure edges occasionally followed by cupping. The vessels of the eye-ground are usually contracted.

Carbon-bisulphid.— This substance causes amblyopia in persons who are employed in handling gutta percha. The symptoms are somewhat analogous to those of alcohol and tobacco amblyopia. In most cases there is a decrease of central vision associated with central scotomata for red and green. In many cases the scotoma becomes absolute. It is a bilateral affection. Ophthalmoscopically there is no typical picture, in some cases nothing abnormal being seen. Optic neuritis and perineuritis with atrophy have been described. The pupils show no typical changes. Anesthesia of the cornea and conjunctiva occasionally occur.

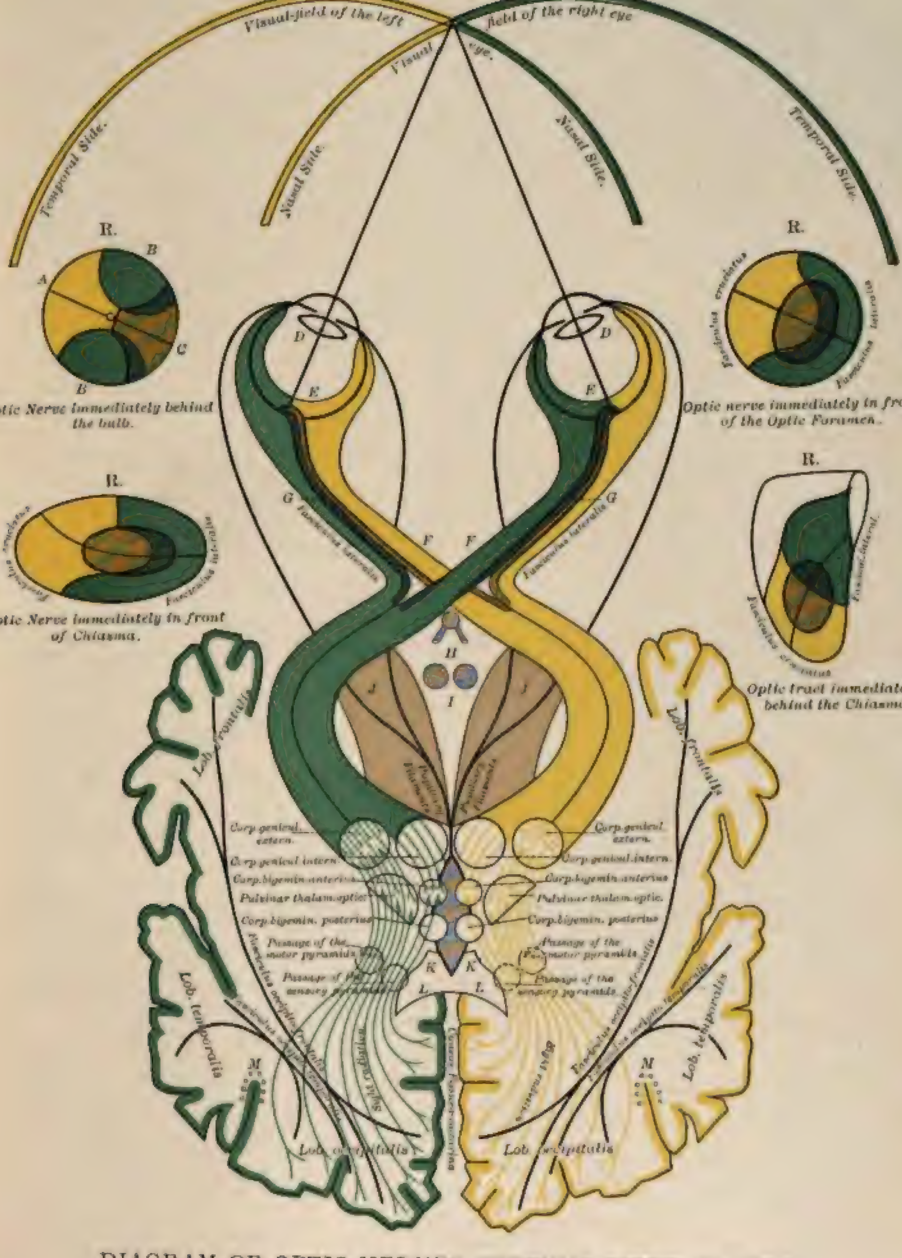


DIAGRAM OF OPTIC NERVES SHOWING SIGHT PLANES.

Nitrobenzol.—This substance, besides causing visual disturbances, primarily affects the blood itself. It usually affects those employed in the manufacture of anilin dyes. Inequality of the pupils, which are sometimes dilated and sometimes contracted, has been observed.

Dinitrobenzol causes visual disturbances in those working with *roburite*, the symptoms being not unlike those in quinin amblyopia (*q. v.*) The ophthalmoscope often shows venous congestion and constriction of the arteries. The intensity of the poison is also shown by yellowish discoloration of the sclera, blueness the lips, and discoloration of the urine.

Male Fern can cause decided disturbances of vision. The ymptoms may begin with intra-ocular pain, headache, tinnitus, and dimness of vision. The affection is generally unilateral, although in many cases both eyes become involved.

Lead.—Persons working with lead are frequently the subjects of visual affection with hardly any appreciable changes in the eye-ground. The eye, however, may be secondarily affected in the case of general poisoning involving other organs, such as the kidney, etc. The poison may directly affect the nervous system. It is generally bilateral. In the case of chronic lead poisoning there may be changes in the fundus similar to albuminuric retinitis (*saturnine retinitis*). The history, occupation, and the cardinal symptoms of the chronic lead poisoning will assist in the differential diagnosis.

Jamaica Ginger.—Blindness following excessive use of Jamaica ginger have been reported by Archibald G. Thomson, J. B. Greene, Edward Stieren, Dunn, and others. The symptoms are not unlike that of methyl alcohol amblyopia, the latter substance being undoubtedly a frequent source of adulteration, as shown by Harlan.

Coffee.—It has been known for some time that coffee can produce amblyopia. Among modern authors it is mentioned by Ball, De Schweinitz, A. E. Bulson, Jr., Wing, and others.

Among other substances causing visual disturbances may be mentioned *tea*, *cocoa*, *camphor*, *salicylic acid*, various *ethereal oils*, and *copper*. Galezowski reports a case where a musician contracted copper amblyopia from the mouthpiece of an instrument.

Prognosis.—The prognosis depends upon our ability to remove the cause and the extent of destruction of the nerve elements. Where wood alcohol has been a factor the prognosis is grave, both for life and vision. When due to the toxic effects of drugs the restoration of vision may be perfect, as in those cases due to alcohol, tobacco, and lead. In quinin amblyopia the prognosis should be guarded, as even in cases where the central vision improves, *peripheral contraction of the visual fields may remain.* In carbon-bisulphid poisoning the prognosis is usually good. The statistics of the Ophthalmological Society of the United Kingdom show 33 per cent of cures, 25 per cent of improvements, and only 20 per cent of little or no improvement.

Treatment.—The uremic, diabetic, and malarial forms require treatment applicable to the respective diseases. Tobacco and alcoholic amblyopia require *immediate* and *absolute* withdrawal of the drug. Turkish baths every second day until five baths have been taken. Tincture of nux vomica, ♏ xv (1.0) t. i. d., increasing to gtt. j (0.06) per dose each day until ♏ xxxv (2.3) t. i. d. are being administered, after which reduce dosage to ♏ xv (1.0) t. i. d. Strychnin hypodermatically, gr. $\frac{1}{30}$ (0.002) to gr. $\frac{1}{20}$ (0.0032), has given good results. Electricity, in the form of the high-frequency current, two minutes to each eye daily until five or ten applications have been made, is valuable, the current being very weak, of such a strength that the purple rays are just visible in the glass vacuum electrode. As an adjunct to the above the constant application of compresses moistened with the following lotion is grateful and of value:

℞ Liquoris plumbi subacetatis diluti	. . fl ʒij ;	8.00
Tincturæ opii, Tincturæ belladonnæ,	. . . . āā fl ʒjss ;	6.00
Tincturæ arnicæ	. . . . fl ℥j ;	30.00
Aquæ camphoræ, Aquæ destillatæ,	. . . . āā q. s. ad fl ℥iv ;	120.00

Misce. Ft.

When wood alcohol is the cause, cautious pilocarpin diaphoresis with potassium iodid and stimulation by strychnin, hypodermically, constitutes the most effectual treatment. Lead amblyopia

requires the daily use of magnesium sulphate purges in conjunction with potassium iodid, gr. x (0.6) t. i. d., in addition to nux vomica, baths, and electricity. Dilute hydrobromic acid, ♏ xx (1.2) t. i. d., has been found to be particularly efficacious in amblyopia following large doses of quinin or when the same effect has been produced by small dosage in an individual displaying marked idiosyncrasy. In all cases of amblyopia when the cause is obscure the urine should be carefully examined and electricity, the high-frequency or galvanic current, as a curative measure should be tried.[1]

OPTIC-NERVE ATROPHY

A diminution in the size with a corresponding diminution in the function of the optic nerve due to the wasting and shrinking of its fibers and their replacement by connective tissue. It may occur as a primary affection (*primary optic atrophy*), or it may be secondary to some other disease of the optic nerve (*post-papillitic atrophy*) of the eye.

PRIMARY OPTIC ATROPHY

Primary optic atrophy is also known as gray degeneration of the nerve, and is progressive in character, being unassociated with any previous inflammation of the nerve. The ophthalmoscopic appearance presented by it consists in a sharply defined disk of a white or grayish or bluish-white color. The margins are regular, and the papilla is smaller than usual. The minute blood-vessels normally present upon the disk are entirely absent. A saucer-shaped depression is frequently seen upon the head of the nerve which resembles somewhat the cup of glaucoma. The lamina cribrosa is plainly seen at the bottom of this excavation. The retinal vessels appear normal in some cases, but a diminution in the caliber of the arteries is not infrequent. One of the early signs is the undue broadening of the scleral ring.

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[1] For an exhaustive consideration of the subject the student is referred to the following works: Lewin and Guillery, "Die Wirkungen von Arzneimitteln und Giften auf das Auge," Berlin, 1905; De Schweinitz, "The Toxic Amblyopias," Philadelphia, 1896; and Uhthoff's contribution to the Graefe-Saemisch *Handbuch der gesammten Augenheilkunde*, vol. xi, 2, 1901.

... usually follows some disease ... the most frequent being locomotor ... disease that the early ap- ... seems to postpone the appearance ... such as the lightning-like pains and ... among the other diseases of the ner- ... optic atrophy may be mentioned ... and tumors of the brain. Less ... syphilis, malaria, diabetes, acro- ... conditions. It may arise ... nerve, due to a great variety of ... without any apparent cause what- ... middle life, and its course is

SECONDARY ATROPHY

... the optic nerve occurs as a termination ... adjacent ocular structures, and is ... postpapillitic optic atrophy. Its ori- ... connective tissue that remains upon ... white or grayish color, and causing ... outline and obscuration of the mar- ... tissue also serves to hide the lamina cri- ... capillary vessels. The veins of the retina ... and tortuous, while the arteries become ... by white streaks at their borders, due ... perivascular lymph sheaths. This form ... follows retinitis pigmentosa, and in such ... grayish-red or yellow waxy appearance. ... of optic atrophy always follows disease ... It is a common sequel to papillitis and ... the terminal stage of neuroretinitis. ... other degenerations of the retina. Em- ... artery of the retina, thrombosis of the veins, ... followed by it. Injury to the optic nerve ... also, but these seldom become manifest ... several weeks.

... forms of optic atrophy the symptoms of ... alike. A marked reduction in the visual

acuity is one of the first manifestations. The visual field becomes contracted, first for colors and later for form. The light sense becomes diminished and scotomata make their appearance. Color blindness soon follows, being at first for green and later for red and blue. Although slow in its course, it tends to progress steadily and eventually terminates in blindness. In compete atrophy the pupil is dilated, the iris motionless, and vision *nil*.

Diagnosis.—The distinction between optic atrophy and other ocular affections is made largely by the use of the ophthalmoscope, but the examiner should be careful not to confuse the condition with variations in the color of the disk as the result of congenital or senile changes. The differentiation of the two varieties of optic atrophy cannot always be made from the ophthalmoscopic picture alone, but frequently requires the consideration of the associated symptoms and history.

Treatment.—Therapeutic measures should always be directed toward the underlying cause, as the atrophy itself is not amenable to treatment. A course of mercury and the iodids and galvanism may be employed, but the results are not very encouraging. Occasionally the progress may be arrested by the administration of strychnin, nitroglycerin, and amyl nitrite. The subcutaneous injection of strychnin in this condition is highly recommended. Hot baths with leeches to the temple have been suggested, and drugs, such as antipyrin, silver nitrate, arsenic, santonin, and phosphorus have been employed.

Optic atrophy sometimes follows blows upon the back of the head and concussion of the brain. Instances of this infrequent condition have been reported by Mackenzie and others. In these cases the patient usually regains consciousness and returns to his daily routine to be attacked in from six weeks to three months with rapidly progressing loss of sight that terminates in incurable blindness. At this time ophthalmoscopic examination will show unmistakable signs of optic atrophy. The pathology of these cases is obscure, but it is probable that hemorrhage occurs in the psychosensory centers in the cerebral cortex at the time of the accident, and the subsequent changes render these centers useless, and the optic nerve undergoes atrophy from disuse and lack of stimulation.

Three cases occurring in the experience of the author exemplify this condition very well. The first was a sailor who was struck by a belaying pin on board ship and was rendered unconscious. He was taken to a near-by hospital and was discharged when consciousness returned. At the end of a month his sight began to fail, and in three months from the injury blindness was complete in both eyes. Examination of the fundus oculi revealed well-marked optic atrophy in both eyes. The second case was that of a policeman who was struck in the occipital region with a brick while attempting to quell a riotous disturbance in this city. On being admitted to the hospital a diagnosis of cerebral concussion was made, and the patient was placed in bed until reaction occurred, after which he was discharged. He returned to his work, but was soon forced to abandon it on account of failing eyesight. This progressed rapidly and optic atrophy was diagnosed. Subsequently he became totally blind. The history of the third case is similar to that of the preceding. An Italian laborer while working upon a railroad was struck by a locomotive and rendered unconscious. His recovery from the injury was prompt, but the sight began to fail, and he became blind in about three months. The characteristics of optic atrophy were very distinct in each eye in this case.

Prognosis.—The ultimate termination of both forms of atrophy is complete or partial blindness. In secondary atrophy the blindness is proportionate to the degree of the primary inflammation.

HEREDITARY OPTIC-NERVE ATROPHY

This rather unusual condition was first described by Leber in 1871. Klopfer, in 1898, in his dissertation brought the literature up to date, and Hormuth in 1900. The affection generally begins about the twentieth year, but may vary from the fifth to the sixty-seventh year (Hormuth). The disease is bilateral, although one eye may be affected first. The failure of vision may be rapid at first, and may subsequently improve, even after complete blindness (Leber). In most cases there is a central scotoma. The cause is not known. As the disease progresses optic atrophy occurs.

TUMORS OF THE OPTIC NERVE

Morbid growths occurring along the course of the optic nerve constitute a very rare condition, only about 130 cases of which have been recorded in literature. They may be found at any period of life, but occur with the greatest frequency before the age of twenty-one years. They are usually situated midway between the globe and the optic foramen.

Symptoms.—In all growths of the nerve there is slow and gradually increasing protrusion of the eyeball forward and outward, due to the increase in the orbital contents. Not infrequently the exophthalmos is so great that the eyelids fail to cover the cornea, and a suppurative inflammation of that structure is liable to occur from its exposure. The motion of the eye is not restricted by the growth and its center of rotation is not displaced. The tumor is usually soft and may be palpable. Pressure upon it rarely gives rise to any pain. An optic neuritis follows sooner or later, and vision becomes markedly impaired. The pupil may become immobile in such cases, but the consensual reaction can always be obtained. The ophthalmoscope reveals nothing characteristic of the condition. The interference with the circulation in the nerve induces distention of the retinal veins and edema of the papilla. With the occurrence of optic neuritis the usual alterations in the appearance of the disk take place, to be followed later by atrophic changes.

Varieties.—As a general classification may be mentioned intradural and extradural tumors. They may be myxosarcomas, endotheliomas, fibromas, gliomas, gummas, or tubercles. Metastatic carcinoma has been observed by Holden (*Archives of Ophthalmology*, September, 1902), but is extremely rare. Although blindness was present there were no abnormal changes visible in the fundus. The common growths are not malignant, in that they do not tend to recur or give metastasis in the internal viscera. In the early stage, at least, all are encapsulated by the fibrous sheath of the nerve. Byers, as described in a classic monograph, has collected and classified 102 cases of primary intradural optic-nerve tumors.

Treatment.—This consists in removal of the tumor alone, enucleation of the eyeball and tumor, or exenteration of the orbit.

[illegible] is perhaps the best mode of treatment, and shoul[illegible] [illegible] by a course of antisyphilitic treatment.

[illegible], Colloid Growths (Drüsen).—These may o[illegible] [illegible] head of the optic nerve. The appearance they pre[illegible] [illegible] characteristic and consists in translucent ma[illegible] [illegible] of a bluish-gray color, more or less mulbe[illegible] [illegible] situated upon the disk, and in extensive cases obscur[illegible]

[illegible] Colloid Growths (Drüsen). (Author's ca[illegible]

[illegible] vascular in origin, arising from the c[illegible] [illegible] disk, and in some cases from the la[illegible] [illegible] at the disk margins. The exact caus[illegible] [illegible] inquiry will serve to elicit a history of [illegible] [illegible] most cases. Calcification of the nodu[illegible] [illegible] The condition is seldom encountered [illegible] [illegible] comparatively frequent in Germany and Ru[illegible] [illegible] factory treatment. The growths them[illegible]

Blindness occurring twelve or eighteen months after birth is not infrequent in syphilitic children, in whom a basilar meningitis may be demonstrated. Microcephalus is the rule in such cases, and the patient usually remains an imbecile. Transient amaurosis is sometimes encountered as a sequel to infantile convulsions.

Amblyopia exanopsia is a variety in which some abnormal condition of the eye is the direct cause. This may be present at birth, but usually is not manifested until development of the child begins. It is dependent upon some high ametropic error in the affected eye. Usually anisometropia is present. The images are improperly focused, if at all, and the retina is deprived of the stimulation necessary for its development. In exceptional cases an excentric macula is formed. The coördination of the ocular muscles is impossible on account of the failure of the retina to send afferent impulses to the centers for muscle equilibrium, and strabismus results. It is also brought about in an effort to suppress the blurred image of the unsound eye. Correction of the ametropia and muscle exercises constitute the treatment.

In young children marked blepharospasm due to spasm of the orbicularis muscle incident to inflammatory diseases or errors of refraction is not infrequently attended by a temporary suspension of vision even after relaxation has occurred.

In youths of both sexes between the ages of eight and thirteen years there is sometimes found a temporary loss of vision independent of any structural change, and characterized by contraction of the visual field and a marked diminution in the central vision. It is not hysterical in nature, but results from some functional disturbance of the retina. The application of the constant current with the suspension of all close work bring about prompt restoration of vision.

Temporary blindness may arise from excessive exposure to light from bright surfaces. Lightning flashes, calcium lights, snow, etc., often induce this condition. Excessive use of the eyes, with exhaustion of the retina, is also a cause. Exhaustion, such as follows neurasthenia, excessive sexual intercourse, and diseases of the genitals, may be included as etiologic factors.

Amblyopia may follow excessive hemorrhages, usually not appearing until eight or ten days after their occurrence. The

form following uterine hemorrhage gives the most favorable prognosis.

A sudden diminution in vision may also follow concussion of brain or of the optic nerve itself. This is temporary in character, and results from injuries to the head, particularly in the occipital region, or blows upon the globe of the eye. Permanent blindness following such injuries indicates hemorrhage, laceration, rupture, or other irreparable injury to the optic nerve or visual centers.

Feigned Blindness (*Pretended Amblyopia; Malingering*).—This may be a part of a general manifestation of hysteria, or it may be the result of an attempt to avoid conscription, or to secure damages, or for some similar object.

Hysterical amblyopia is most common in young girls or young women, but may occur in males of sedentary habits. It is usually unilateral, and is characterized by contraction of the visual fields, often with reversal of the color fields, varying degrees of diminished vision, crossed amblyopia, scotoma, and hemiopia. Among the other symptoms of which the patient complains may be included photophobia, flashes of light, blepharospasm, corneal anesthesia, ptosis, etc. The intensity of these manifestations varies from time to time. Careful examinations at frequent intervals fail to reveal any abnormality in the dioptric mechanism or the eye-ground. All the other distinctive features of hysteria, as the characteristic convulsions, emotional attacks, hysterogenic zones, anesthesia, and paralyses, may be demonstrated by careful observation of the patient. The duration is indefinite, but the response to the ordinary treatment for hysteria is prompt and gratifying.

Tests for Malingering.—In most malingerers an inability to see out of one or both eyes is the only complaint. To determine the truthfulness of such statements it is necessary to employ certain tests. One of the most satisfactory of these consists in covering the eye supposed to be blind, and then placing a *prism* before the sound eye so that its base will cross the center of the pupil. This induces monocular diplopia. The blinder is then removed quickly and the prism is shifted so that binocular diplopia will be produced. Another test consists in producing binocular diplopia by means of a prism placed base up or down before the sound eye. The inaccuracies in the answers of the patient will serve

to detect the condition. Stilling's colored letters may also be employed. They consist of colored letters upon a dark background, and are rendered invisible by looking through glasses of complementary colors. The placing of a high convex spherical lens before the sound eye and asking the patient to read as the card is carried away is also of value (Harlan). If the patient reads at a distance greater than the focal distance of the lens, vision is intact in the eye said to be blind.

One of the most ingenious tests devised for the determination of blindness is the card upon which the word "FRIEND" is spelled in alternate green and red letters. The letters are painted

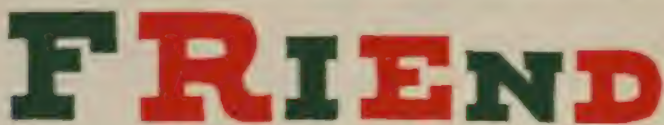

Fig. 129.—Test for Malingering.

upon glass on a black background, becoming visible only when held up so that the light may shine through them.

The patient is seated a few feet from the chart and a trial frame is placed before the eyes. Both eyes are allowed to be used in order to disconcert the individual, using a red glass before one eye and a green glass before the other in a trial frame. If able to read the entire word, blindness is absent. If the eye before which the green glass is placed is blind the green letters will be suppressed by the red of the glass of the other eye, and the red letters will be intensified so that the patient will spell only the word "RED."

If blindness is absent, fusion of the images of both eyes will occur and the entire word "FRIEND" will be seen. The findings of this first test may be verified by placing a green glass before the eye in place of the red disk. Blindness will be indicated by the patient reading the word "FIN" in green letters. Reading of the entire word indicates malingering.

Pretended blindness of both eyes should be investigated by carefully watching the individual. The following test should be applied, according to Priestley Smith and Edward Jackson: Place a lighted candle in front of the patient and a 6-degree prism with base out before one eye. If there is vision the eye behind the

prism moves inward, and when the prism is removed the eye will again move outward.

Reflex Amblyopia.—Reflex disturbances of the nervous system have been reported as causes for temporary diminution of vision in a number of well-authenticated cases. Irritation of the fifth cranial nerve, particularly in connection with disease of the teeth, is the most frequent. The consultation of a dental surgeon is advisable in such cases.

Amaurosis fugax, or scintillating scotoma, is an infrequent visual disturbance characterized by obscuration of the visual field by a wavy cloud. It is usually homonymous and is attended by migraine. It may arise from syphilis, eye-strain, and gastric disturbances, being largely reflexive in character. The tension undergoes no alteration and differs from certain types of glaucoma in this particular.

Nyctalopia or day-blindness is a condition in which vision is best at dusk or in dull light. It is most common in spring and fall, and is a symptom of debility. It is also associated with tobacco amblyopia and other conditions attended by central scotoma. The condition is in addition a manifestation of opacities of the cornea and lens, an improvement in vision being brought about by the dilatation of the pupil in the subdued light. Sailors, especially those in the tropics, find the light most annoying.

Hemeralopia or night-blindness seldom occurs as a functional disorder except in cases of general debility, starvation, anemia, and scurvy. It is more frequently associated with retinitis pigmentosa, xerosis of the conjunctiva, and similar degenerative conditions.

Micropsia is a visual defect, in which the size of objects seems diminished.

Megalopsia is the opposite condition, and is characterized by an overestimation of the size of objects.

Metamorphopsia is a visual defect in which the objects seen appear distorted.

Micropsia and megalopsia may be due to errors of refraction or disease of the visual centers. Metamorphopsia may arise from high degrees of ametropia, but is usually due to the presence of an inflammatory exudate in the retina or choroid, as well as changes in the fibers of the lens.

Enucleation is perhaps the best mode of treatment, and should be preceded by a course of antisyphilitic treatment.

Hyaline, Colloid Growths (Drüsen).—These may occur upon the head of the optic nerve. The appearance they present is particularly characteristic and consists in translucent masses of excrescences of a bluish-gray color, more or less mulberry-shaped, situated upon the disk, and in extensive cases obscuring

FIG. 128.—HYALINE OR COLLOID GROWTHS (DRÜSEN). (Author's case.)

its margins. They are vascular in origin, arising from the coats of the vessels of the disk, and in some cases from the lamina vitrea of the choroid at the disk margins. The exact cause is unknown, but careful inquiry will serve to elicit a history of previous traumatism in most cases. Calcification of the nodules may eventually occur. The condition is seldom encountered in this country, but is comparatively frequent in Germany and Russia. There is no satisfactory treatment. The growths them-

selves have no serious significance unless an enormous size is attained, which may amount ophthalmoscopically to 12 or 14 D. (Parsons). Intercurrent affections of the tunics of the eye may induce impairment of vision.

INJURIES OF THE OPTIC NERVE

The entrance of foreign bodies into the orbit may involve the optic nerve. In such cases atrophy follows but does not manifest itself at once. Rupture of the nerve is attended by immediate and complete blindness. Concussion of the nerve or hemorrhages into its sheath may occur with suspension of vision more or less permanent. A great variety of injuries of the optic nerve may follow traumatism to the skull, particularly fracture of the base and of the orbit. Vision is lost and atrophy follows. In fracture of the base of the skull the hemorrhage travels beneath the meninges and sheath of the nerve, causing loss of vision, and eventually, in the course of three or four days, appears beneath the conjunctiva. Hemorrhage into the sheath of the nerve is also said to occur in those cases of sudden blindness following severe hemorrhage, especially from the gastro-intestinal tract. The treatment, aside from those measures directed toward the underlying cause, is expectant in character.

VISUAL DISTURBANCE OF FUNCTIONAL ORIGIN

Amaurosis is the technical term for partial or complete blindness, while amblyopia is applied to diminution in visual acuity. In both conditions there is no discoverable structural change in the eye or optic nerve. As both terms indicate differences in degree only, the first is falling rapidly into disuse.

Congenital blindness is the earliest form encountered, and may be monocular or binocular. It is first noticed when the child begins to walk by its inability to avoid gross objects. If the condition is monocular, the blind eye will fail to fix and strabismus becomes manifest. In such cases nystagmus is a frequent accompaniment. Blindness at birth may also be due to some congenital malformation of the skull with imperfect development of the brain.

rate components of a mixture of sound waves of different frequencies.

When, however, the ether waves are not mixed together, but are separated from one another, as by passage through a prism, the eye is capable of transmitting the separate color sensations to the brain.

Kinds of Colors.—While objectively—that is, so far as the ether waves are concerned—colors differ from one another only in the vibration frequencies or wave-lengths of the exciting ether waves, they differ subjectively from one another in a variety of ways. Colors may, therefore, be divided into the following classes:

1. *Simple* or *prismatic colors* are those produced by ether waves of a single frequency.

2. *Mixed colors* are those produced by the simultaneous action of a number of mixed ether waves of varying frequencies or rates of vibration.

3. *Fundamental* or *primary colors,* a name sometimes given to three simple or prismatic colors, such as red, green, and violet, the simultaneous action of various mixtures of which is able to produce on the retina all the colors of the solar spectrum.

4. *Fatigue* or *contrast colors* are those that are seen by looking at a colored field and then at a field of white light.

5. *Complementary colors,* or any two colors a mixture of which, simultaneously affecting the retina, are capable of producing the sensation of white light.

Complementary Colors.—The complementary prismatic colors are as follows:

Red	Complementary color	Greenish-blue
Yellow	" "	Indigo-blue
Orange	" "	Cyan-blue
Greenish-yellow	" "	Violet
Green	" "	Purple
White	" "	Black

Any two complementary colors, when mixed together and permitted to act simultaneously on the retina, are capable of producing in the eye the sensation of white light.

Color Constants.—Each color sensation may be further subdivided into the following color constants—i. e., (1) hue, (2) purity, and (3) luminosity or brightness.

1. *Hue* is the result of those differences which depend on the wave-lengths of the ether waves producing them. In the case of purple, which is not a natural color, but only a color sensation as the result of the admixture of blue or violet with red, the nearest combination of two spectral colors is taken; likewise with white.

2. *Purity.*—By purity of a color is meant its freedom from admixture with white light, a pure color containing no such admixture.

3. *Luminosity or Brightness.*—This property depends objectively on the amplitude of the ether waves or the amount of energy they possess. It depends subjectively on the sensitiveness of the retina to the particular photogenic stimulus produced by the ether waves.

Sensation of White.—There are three ways in which the sensation of white, or the so-called white light, can be produced—i. e.:

1. By the simultaneous action of mixtures of all the colors existing in the spectrum of sunlight, or of the light emitted by a body whose temperature is raised to a white incandescence.

2. By the simultaneous action of a mixture of two complementary colors, such as red and greenish-blue, orange and cyan-blue, etc.

3. By the simultaneous action of all the three primary colors.

THE THEORIES OF COLOR-SENSE

YOUNG-HELMHOLTZ THEORY

The Young-Helmholtz theory (first proposed by Thomas Young in 1807, and subsequently modified by Helmholtz) assumes that the terminal fibrils of the retina are arranged in three distinct sets for the reception of these three primary colors—red, green, and violet. These groups correspond to the three colors, and acting simultaneously induce the sensation of white. Red light entering the eye affects to the greatest extent the group of filaments known as the red sensitive elements, but also affects the others to a slight degree. In like manner green and violet

are perceived by their corresponding sensitive elements. The absence or imperfect development of the retinal area set aside for one of these primary colors will cause this color to be seen as if composed of the two remaining colors, thus giving rise to color-blindness corresponding to the deficient color elements.

FIG. 130.—REPRESENTATION OF COLOR PERCEPTION, ACCORDING TO THE THEORY OF YOUNG AND HELMHOLTZ.

The abscissa represents the spectrum, the colors of which are red, *r*, orange, *o*, yellow, *g*, green, *gr*, blue, *bl*, violet, *v*; the curves which rise above the abscissa show graphically the sensitiveness of the three sorts of fibers in the retina towards rays of different wave lengths. The ordinates, r^1, gr^1, and v^1, indicate the intensity of the stimulation of the fibers produced by red, green, and violet rays respectively. *A* gives the curve representing the sensitiveness of the fibers for the perception of red; *B*, that of the fibers for the perception of green; *C*, that of the fibers for the perception of violet. In *D*, all three curves are represented at the same time. *E* shows the curves of sensitiveness of a red-blind eye in which the fibers for the perception of red are assumed to be wanting.

HERING THEORY

This theory assumes the existence of three separate visual substances in the retina. Each of these substances is decomposed by the action of light and is renewed when the eye is permitted to rest in the dark. Both the decomposition and the renewal of the visual substances result in the production of color sensation.

The Hering visual substances are divided into three sets of two each—i. e., (1) white-black substance; (2) red-green substance; (3) blue-yellow substance.

When the black-white substance is decomposed (*katabolic change*) the sensation of white is produced. When this sub-

stance is renewed (*anabolic change*) the sensation of darkness results.

When the red-green substance is decomposed the sensation of red is produced, and when it is renewed the sensation of green results.

When the yellow-blue substance is decomposed the sensation of yellow is produced; when it is renewed the sensation of blue results.

Red light produces the sensation of red by decomposing the red-green substance. Orange light produces the sensation of orange by decomposing both the red-green and the yellow-blue substances. Yellow light produces a sensation of yellow by decomposing the yellow-blue substance, the red-green being then in equilibrium. Green light produces the sensation of green by the renewal of the red-green substance, the yellow-blue being now in equilibrium. Blue light produces the sensation of blue by the renewal of the yellow-blue substance. Violet light does the same, though to a less degree.

Before the latest, and probably the most comprehensive theory, that of Edridge-Green, is described, it will be necessary to give a brief description of the at-one-time-believed *photo-chemical* basis of vision and of the *visual purple.*

PHOTOCHEMICAL BASIS OF VISION

It was at one time thought that the rods and cones of the retina vibrate in unison with the different wave-lengths of light that fall on them. This, however, is no longer credited. The vibrations of the luminiferous ether are far too rapid to permit any such motions to take place.

As above explained, the impulses that affect the eye are not the result of transmitted vibrations, but are probably caused rather by molecular changes set up by some obscure photo-chemical process in some chemical or visual substance, such as the visual purple, or in certain colored substances such as those assumed by the theories of Young-Helmholtz, Hering, and others. Under the influence of these changes, chemical substances result that cause molecular changes in the retinal elements. These changes, being transmitted through the optic nerves to the brain, cause

sensations of light, color, and form. In order to produce these effects it is necessary that the photogenic waves be stopped and absorbed.

Rhodopsin and Other Visual Substances.—There exists in the retinal epithelium a special brown pigment known as *fuscin* that is believed by some to possibly fulfill the above function. When *rhodopsin*, or the **visual purple,** was first discovered in 1876, it was believed that this substance fulfilled the function of stopping and absorbing the photogenic waves, for rhodopsin undergoes decomposition by light being decomposed first into a *visual yellow* (*xanthopsin*), and subsequently into a *visual white* (*leukopsin*). This appeared especially probable since the visual efficiencies of the rays corresponding to the different colors were relative to their photochemical effects on the purple.

EDRIDGE-GREEN THEORY

This theory may be defined as follows: The cones of the retina are insensitive to light, but are sensitive to certain chemical changes set up in the visual purple. The latter substance is liberated from the rods when the light falls upon the retina, is then diffused over the fovea centralis and other parts of the retina, the impulse being then transmitted through the optic-nerve fibers to the brain. According to this theory, we may look to the impulse itself for the physiological basis of *light*, and to the quality of the impulse for the physiological basis of *color*. The Edridge-Green theory further assumes that there is a special perceptive center in the brain by which the quality of the impulse is perceived, within the power of perceiving differences possessed by that center or portions of that center.

COLOR-BLINDNESS (DALTONISM)

In certain cases there exists an inability to distinguish certain colors, known as color-blindness. This defect can be divided into two kinds—i. e., (1) total color-blindness, (2) partial color-blindness.

In total color-blindness (achromatopsia) the color sensation is entirely absent. All objects appear of different degrees of white and black, or present the appearance of the objects in an

engraving or photograph. Total color-blindness is comparatively rare. Its cause (Young-Helmholtz theory) is ascribed to the absence of the three sensitive sets of nerve fibers of the retina with their associated visual substances. In the Hering theory the cause of total color-blindness is the absence of the red-green and the yellow-blue colored substances, the white-black substance alone remaining.

In partial color-blindness generally only one, though sometimes two, of the color sensations are wanting.

CONGENITAL COLOR-BLINDNESS

This form of color-blindness is by far the most common. It appears to have existed in the human race from the earliest times. The earliest described case of congenital color-blindness appeared in the *Philosophical Transactions* of 1777. The next case described was that of the English chemist, Dalton, in 1794. Seebeck made a systematic study of color-blindness about 1836. Since this time a great amount of study has been devoted to the subject.

According to careful tests it appears that about 3.59 per cent of males and only 0.88 per cent of females possess congenital color-blindness. Generally speaking, both eyes are affected, though sometimes only one eye is color-blind.

In the case of congenital color-blindness a careful examination of the eyes shows no other departure from the normal condition than the absence of the color sensations. The defect appears to exist among all classes of society and all races of men. According to Horner, the sons of daughters whose fathers are color-blind are especially apt to inherit this defect, although exceptions to this have been noted (Schoeler, *Jahresbericht*, Stockholm, quoted by Parsons). For this reason color-blindness is apt to be especially common among sects or races that intermarry, as the Quakers and the Jews.

ACQUIRED COLOR-BLINDNESS

Color-blindness may be acquired in after life in a variety of ways. It may result from an atrophy of the optic nerve. It is also produced by a variety of special diseases or conditions, such

as cerebral tumors, locomotor ataxia, paresis, traumatism, syphilis, alcoholic and tobacco poisoning, etc. Acquired color-blindness is generally complete. When partial it can best be detected at a distance.

Prognosis.—It is now generally recognized that congenital color-blindness is incurable. At one time, owing to the investigations of Favre, of Lyons, it was believed that this defect could be cured by exercising the color sense. For this purpose, Favre distributed packages of colored yarns among school teachers for use by the children. These packages contained various shades of the prismatic colors, the children being taught the proper names of the colors by the teachers. It is now recognized that deductions based on these investigations are worthless, since the methods adopted failed to distinguish between color-blindness and color-ignorance.

COLOR-IGNORANCE

Color-ignorance, or the inability to properly name different colors, may be due to color-blindness, or may result only from defective knowledge of the names of the colors, so that in making tests for the detection of color-blindness, unless care is taken to eliminate the effects of color-ignorance, the results will be untenable.

The necessity for color names is of decided practical importance. It is largely due to the efforts of Edridge-Green that this fact is being impressed upon the profession. This author's prediction that if color names were ignored in the Board of Trade tests, normal-sighted persons would be rejected, has been fulfilled, as shown by the following results, quoted from the author himself: "Over 38 per cent one year, and more than 42 per cent another year, of those who appealed were found to be normal-sighted, and to have been rejected wrongly."

Under certain circumstances the existence of color-ignorance is as objectionable as that of color-blindness. In navigation it is often necessary that the lookout man should, without a moment's delay, be able to report to the officer in charge the name of a colored light. His failure to do this, whether due to color-ignorance or color-blindness, might easily produce a disaster. For this reason the existence of color-ignorance as well as color-

blindness should prohibit the employment at certain kinds of work, such as on railroads or in navigation. While color-ignorance can be easily overcome by education, color-blindness, when of the congenital type, is incurable.

TESTS FOR COLOR-BLINDNESS

Holmgren's Worsted Test.—This test is based on a modification of a method proposed by Seebeck and first actually employed by Wilson. It possesses the great advantages of shortening the time, for a satisfactory examination, from one hour to one minute.

In the Holmgren test the colored worsteds consist of three test skeins of light green, rose, and bright-red respectively, together with a great number of such colors as are apt to be confused by the color-blind, and are therefore called "confusion colors." These are red, orange, yellow, yellow-green, pure green, blue-green, blue, violet, purple, pink, brown, and gray, with several shades of each color and five gradations from the deepest to the lightest of each tint. Pale shades of reds, pinks, browns, and yellows should be especially well represented. The entire group of Holmgren's worsteds should number some 150 skeins, of the same size and general appearance, the colors alone differing.

In the Holmgren test the examinee is requested to select from a heap of various-colored worsteds all resembling a match skein in color and place them by its side.

The examination is conducted as follows:

First Test.—The pale-green match skein is employed. This must be a pure green—i. e., neither a blue-green nor a yellow-green. This skein is taken from the pile and placed on one side. The examinee is required to select from the heap of colored worsteds all other skeins that match it in color and place them by the side of the sample. It should be clearly explained that there are no two skeins exactly alike in the heap, and that what is wanted is that the examinee should find a similar color of a lighter or darker shade. This test can best be conducted by requiring the examinee to find the desired match by using his eyes rather than his hands. If there is any doubt that the ex-

aminee has failed to understand what is required of him, the examiner should show him what is required, being careful to afterwards place back in the pile all the colors selected except the sample skein. When many are to be examined, time can be saved by instructing all at the same time and permitting them to be present at the examination of those who precede them.

If the examinee possesses the normal color sense he will be able to pick out the lighter and darker shades of green without hesitation. The fact that he includes in his selection skeins whose color inclines to yellow or blue is rather an evidence of ignorance of color names than of color-blindness. If completely color-blind, however, whether to red or green, he will select some confusion color, such as grays, drabs, stone-colors, fawns, pinks, or yellows.

If the examinee selects confusion colors he is thereby shown to be color-blind. In order to determine the nature and degree of his blindness a second test is employed.

Second Test.—The pile of worsted skeins is again mixed and a match skein of rose-color is laid to one side, and the examinee requested to pick out all the lighter and darker shades of this color he can find. The color-blind always select deeper colors, the incompletely color-blind deep purples to match the rose, the complete red-blind will match it with blue or violet, either with or without purple. The completely green-blind will match it with green or gray with or without purple. The violet-blind tend to select blue in the first test, and red or orange, with or without purple, in the second test.

If the first and second tests have satisfactorily determined the existence and character of the color-blindness, further tests are unnecessary. Sometimes, however, an additional test may be of value for the purpose of convincing officials or others that the examinee is unfit for employment. In this case the third test is employed.

Third Test.—Here the sample skein is bright red. The red-blind will match this with greens and brown shades rather than red, while the green-blind will select green and brown lighter than the red. The third test, however, is only of use in cases of marked color-blindness.

Thomson's test consists of forty bundles of variously colored yarns, all of which are numbered and so arranged that the odd

numbers are the match colors and the even numbers are the confusion colors. These yarns may be placed in rotation upon a stick or may be thrown in a heap upon the table in front of the patient. The latter is probably the better method, particularly for those who undergo repeated examinations. The test colors are the green, the purple, and the red, and a selection of not less than ten tints is requisite. The numbers are recorded upon a chart,

FIG. 131.—THOMSON'S TEST FOR COLOR-BLINDNESS.

and the presence of color-blindness is indicated by the even numbers in the report. The odd numbers from 1 to 19 inclusive are the various shades of green, those from 21 to 29 are purple, and those from 31 to 39 are red. The test is based on the same principle as in the preceding one.

In 1894 Thomson devised a modification of the above test in order to overcome some objections that had been urged against the sticks. In the old form of stick the arrangement of the skeins in regular order, the match skeins alternating with the confusion skeins, if discovered would render the test worthless. Thomson, therefore, devised a test by employing two different sets of worsteds which are always kept apart, not only in their corresponding parts of the box, but also in testing the examinees.

The first set consists of a large green sample skein and twenty small skeins of different shades of green with confusion colors of grays, light browns, etc. Each of these skeins is marked by a bangle containing a concealed number from 1 to 20.

The second set consists of a large sample skein of rose-color, with twenty small skeins numbered from 21 to 40. Concealed numbers were placed on bangles as in the first set. In both cases the confusion colors were represented by even numbers.

The method of testing employed is as follows: The worsteds are removed from the green part of the box and placed in a confused mass on the table, the examinee being required to select ten tints to match the large green skein. As soon as this is done the numbers are recorded, the worsted removed, and an examination made with the second set. The red test skein with its confusion colors is omitted because unnecessary.

For the use of the expert, two additional large test skeins are used, one of yellow and the other of blue.

When the yellow test skein is employed the examinee is required to match it, if possible, from the skeins from 1 to 20. If his color sense is not deficient he will decline to do this, or at the worst will select a yellow-green skein. If color-blind, however, he will select several green skeins, which are recorded.

The large blue test skein is then employed, and the examinee is requested to match it with skeins with numbers from 21 to 40. If normal or green-blind he will select blues only; if red-blind he will select a number of rose tints.

Oliver, of Philadelphia, has also devised a useful worsted test. Other modifications of Holmgren's yarn test are the Jeaffreson's test disk, Daae's color table, the embroidery patterns of Cohn, Badal's colored cylinders, Schenke's yarn-covered spools, Donder's pseudo-isochromatic patterns, Mauthner's pigment vials, as well as various forms of chromatometers. Quantitative tests have also been devised.

Edridge-Green Test.—This is divided into three parts: (1) *Lantern test*, (2) *classification test*, (3) *spectrum test*.

1. The *lantern test*, according to Edridge-Green, while sufficient for practical purposes, is not enough for those who desire to have an accurate conception of color-blindness. It consists of a lantern with colored glasses, mounted on slides, which contain the various colors as well as modifying glasses. There is also an iris diaphragm for regulating the size of the light.

2. The *classification test* consists of 4 test colors and 180 confusion colors. The test colors are required to be named, and all of similar colors to be then selected. It is emphasized that a normal-sighted person going through the test must not be watched by the examinee, nor is the latter required to pay any attention to shade. The name given to a color is immaterial, but

naming two of the principal colors readily distinguishable by those who are not color-blind by the same name is considered sufficient reason for rejecting the applicant.

3. *Spectrum Test.*—This is considered the most accurate. The applicant is required to describe the spectrum, some of the middle portion being shown first, the ends being then noted to detect any shortening. Finally, the applicant is asked to select some of the bands which appear to him as having but one color.

Stilling's Pseudoisochromatic Plates.—These consist of 10 separate plates of colored glass, the surface of each of which is marked off into 40 squares. Scattered through these squares are small squares of some other color arranged so as to form letters, numerals, etc. The colors employed, both for the background and for the small squares used for forming the letters, numerals, etc., are such as are not readily distinguished by the color-blind. Fig. 132 shows one of these plates with red letters on a green background. In employing Stilling's plates the colored plate is placed in a good light and the candidate is required to trace the letters, numerals, etc. These plates are of considerable value when employed in connection with different worsted tests already described.

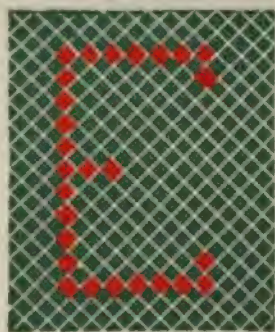

Fig. 132.—Stilling's Pseudoisochromatic Plates.

Lantern Tests.—Various lantern tests have been devised, not only for the purpose of overcoming the objections to the test with colored yarns, but also for more accurately determining the true condition as to color vision of those who can pass Holmgren's test in daylight when one meter distant from the colored objects, and yet who may be absolutely unfit to discharge responsible duties when surrounded by some of the conditions which their positions present. In the lantern tests, of which there are a large variety, the color is presented by the passage of artificial light, generally that of the lamp (semaphore lamps in railway service), through colored glass. William Thomson, Edridge-Green, and Charles H. Williams have each devised a practical apparatus.

Williams' Lantern Test.—This is now in use on various railways in the United States and Canada, and has been found very satisfactory. This lantern picks out small central changes in the macular region, such as the small scotomata for color in tobacco amblyopia, which interfere with the proper recognition of distant signal lights. There have been instances where applicants have passed with the worsteds and failed with this lantern, because the retinal image of the worsted is large enough to extend beyond the affected area of the retina.

FIG. 133.—FRONT VIEW OF WILLIAMS' LANTERN (NEW MODEL), USED FOR TESTING FOR COLOR-BLINDNESS.

One of the principal advantages of this test lies in the simultaneous comparison of colored lights which it gives; either one, two or three colored lights can be shown at one time, and with varying colored areas and intensity of light. In actual service several colors are often shown on one signal post or bridge, and with this lantern many combinations can be shown; for instance, three reds of different shades, two greens and a red, a red, green, and yellow, two reds and a white, etc. The test is conducted as follows:

FIG. 134.—DOUBLE ELECTRIC LAMP USED IN WILLIAMS' LANTERN.

Light both burners of the lamp, taking care not to turn them up so high as to smoke; place the lantern in a darkened room 20 feet from the person to be examined and about on a level with his head, the side of the lantern carrying the disk of colored glasses facing directly toward him. Place the shutters (moved by a rod at the top of the lantern, or a knob above the disk) so that three lights are shown through the largest openings. Turn the disk slowly, so as to show all the different com-

binations of colors, and have the person examined call aloud the names of the colors as shown, designating them thus: "Left green, middle red, right red," etc. Under each color is a distinguishing number, which is lighted at the same time the color is shown, and as the examination proceeds the examiner will note on the record, under the corresponding number, the name given to the color shown. After all the colors have been shown through the largest openings, move the shutters so that the colors are seen through one opening only of the smallest size. Rotate the disk and again note on the record the names given to the colors. Calling a green blue, or *vice versa*, calling a yellow red, or with the smallest opening failing to see the color in No. 7 (cobalt-blue), which transmits less light than the others, will not be considered as serious mistakes, but calling a red light green or a green light red shows that the color perception is too defective to be considered safe in any position requiring the use of colored signal lights.

FIG. 135.—WILLIAMS' LANTERN (INTERIOR VIEW).

As the colors of the glass do not fade, this test is a permanent one, and its record can be referred to at any time.

The colors in the largest-sized openings of the lantern seen at a distance of 20 feet correspond to the apparent size of a 5⅜-inch signal lens when seen at a distance of 160 feet, and the smallest openings at the same distance correspond to such a signal lens at a distance of 1,250 feet. Where an electric lamp can be used, a

double electric lamp with rheostat gives the best illumination for the lantern, for it gives a light which can be regulated in intensity by fixed amounts, and avoids the smell and trouble of the oil lamp.

COLOR-VISION

A condition in which colors are seen which do not exist. It may be of various kinds: erythropsia, or red vision; cyanopsia, or blue vision; xanthopsia, or yellow vision; chloropsia, or green vision; or mixed.

Erythropsia is most frequent after cataract operation and exposure to extremely bright light. It may occur in hysteria and neurasthenia.

Cyanopsia may also arise from cataract extraction, but seldom exists alone.

Xanthopsia is the most frequent form of color-vision, and is present in icterus, yellow fever, acute yellow atrophy of the liver, cerebral concussion (Hilbert), and in poisoning by phosphorus, santonin, amyl nitrite, and picric acid.

Chloropsia may occur in neurasthenia, hysteria, and, according to Hilbert, in hemicrania, nephritis, paresis, syphilis, and tabes.

Mixed color-vision is a symptom of poisoning by drugs that induce delirium in toxic doses, such as cannabis indica and salicylic acid. A variety of mixed color-vision is encountered in glaucoma (iridescent vision), in which the light seems to be surrounded by colored halos or rainbows.

The treatment in all forms of visual color disturbances consists largely in removing the underlying cause, as the condition itself is not amenable to medication.

CHAPTER XIV

DISEASES OF THE CRYSTALLINE LENS

Aphakia—the technical term for absence of the crystalline lens. The condition may be congenital or acquired. The congenital form is rather rare, while the acquired variety is more frequent, being present after cataract extraction and to some extent after luxation of the lens. It is manifested by entire loss of accommodation, deep anterior chamber, trembling iris, and considerable hyperopia.

The treatment consists in correcting the manifest hyperopic defect by convex lenses for distance, and adding an extra convex lens to take the place of accommodation for near work.

DISLOCATIONS

Luxation of the lens may be congenital or acquired.

Congenital Dislocation of the Lens (*Ectopia Lentis*).—Ectopia lentis, as the name implies, is a condition in which the crystalline lens is displaced from its normal position; this displacement, as a rule, is upward and outward, although occasionally it takes place in other directions. The dislocation is usually bilateral, although cases of unilateral displacement have been observed.

Etiology.—The causes of congenital displacement have not been satisfactorily explained, although heredity has been shown to play a most important rôle in this condition. Tiffany mentions a case in which in one family 7 out of 9 children were affected; there was a positive history on the father's side. It is also said to be due to an absence of suspensory ligaments.

Treatment.—In partial displacement without marked disturbance of vision, operative interference is contraindicated. Glasses should be prescribed and given a fair trial, although the results

regarding their use are not entirely satisfactory. An iridectomy may become necessary if there is great interference with vision. If the lens becomes cataractous subsequently it should be removed.

Acquired Dislocation of the Lens.—This variety of luxation is usually traumatic in origin. It may be partial or complete. Its situation varies according to the intensity and character of the violence that produced it; sometimes the lens is found posteriorly in the vitreous, and at others anteriorly in the anterior chamber. In very rare cases attended by rupture of the sclera it may lie beneath the conjunctiva.

FIG. [illegible].—TRAUMATIC DISLOCATION OF THE CRYSTALLINE LENS INTO THE ANTERIOR CHAMBER. (Author's case.)

Etiology.—Acquired luxation of the lens usually follows blows upon the eye by the fist, whip, or stick of wood, kicks, or some similar violence, but may occur in the course of diseases of the eye, such as malignant myopia and choroiditis.

Symptoms.—Displacement of the lens into the anterior chamber may be recognized without any difficulty, as it resembles no other condition and can be detected by the unaided eye. When dislocated into the vitreous chamber it can only be seen by the aid of the ophthalmoscope. The lens may move back and forth through the pupil, depending upon the position of the head and body. The author has had two such cases of traumatic dislocation within three years; in both cases the lenses were calcified. Whenever the iris is unsupported by the lens, it will be found to be tremulous upon moving the eye, a most important diagnostic sign. There may be complete or partial loss of accommodation, depending upon the degree of dislocation of the lens. Monocular diplopia is frequent. Complete dislocation of the lens into the anterior chamber is apt to set up an irritation, and may, especially if

the lens be a large one, by occluding the filtration angle, give rise to glaucomatous symptoms.

Treatment.—Removal of the lens is absolutely necessary when there is a complete dislocation into the anterior chamber of the eye, or when the condition gives rise to serious irritation. The method of procedure will be described under operations for cataract.

Since removal of the lens from the vitreous is a dangerous procedure, it is preferable to allow it to remain, and cases have

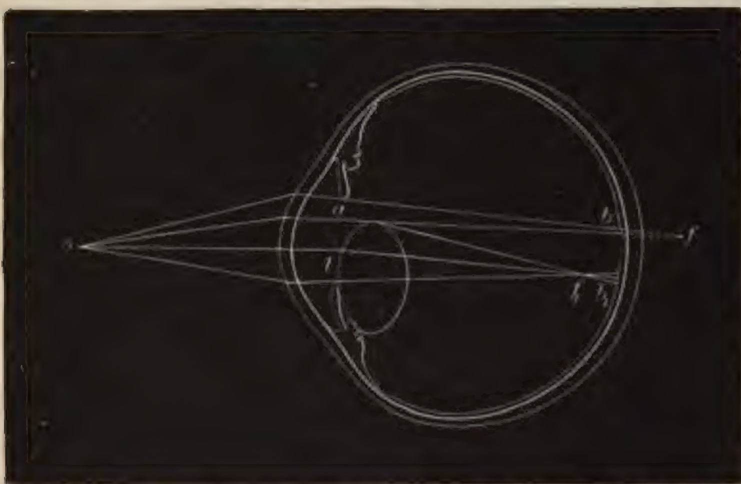

FIG. 137.—SUBLUXATION OF THE LENS. SCHEMATIC.

The lens has sunk so far downward that its upper edge is visible in the pupil. In consequence of the relaxation of the zonula it is much bulged out, and is in contact by its lower border with the ciliary processes, moreover, the lower half of the iris is pressed forward by it. Above, on the contrary, the anterior chamber, owing to recession of the iris, is abnormally deep. Of the beam of rays emitted by the luminous point *o*, a portion goes through the aphakic part, *a*, of the pupil; these rays, on account of the absence of the lens, are insufficiently refracted, so that they come to a focus behind the retina at *f*, and form upon the retina a diffusion circle, *b*. That portion of the beam passing through the section, *l*, of the pupil, which contains the lens, undergoes excessive refraction on account of the increased convexity of the lens, so that the rays intersect in front of the retina at f_1, and form upon the retina a diffusion circle, b_1. This latter gets to lie below the fovea centralis (and below the diffusion circle, b_1, because all rays passing through the lens undergo a deviation downward on account of the prismatic action of the latter. Thus two images of the point *o* are produced upon the retina (monocular diplopia).

been reported in which the lens has occupied this position for years, without giving any serious trouble. For such patients glasses should be prescribed.

If the lens is floating in the vitreous the following procedure may prove successful: The pupil of the injured eye is dilated and

the patient made to lie on his face for several hours in the hope that the lens may gravitate through the pupil; if it does, the pupil is then contracted with eserin so that the lens is held in place in front of the eye, from which position it can readily be extracted through an incision in the middle of the cornea, pressure being exerted above and below. The author has succeeded in removing the lens in this way in four cases.

Coloboma of the crystalline lens is sometimes observed, but is extremely rare and is not amenable to treatment.

Lenticonus is an abnormal curvature of the anterior or posterior surface of the lens. In Webster's case the apex of the lens cone projected into the anterior chamber. It impairs vision somewhat, but is unaltered by treatment. Posterior lenticonus is rare. Correcting lenses are often necessary, but visual acuity is unaffected by other treatment.

CATARACT

Definition.—Any opacity of the crystalline lens, its capsule, or both.

Ordinarily the lens and its capsule are sufficiently transparent to be indistinguishable by the usual examination. Upon careful examination we observe that the lens when viewed obliquely is never perfectly transparent at any period of life. Even during childhood, when we would expect it to be perfectly transparent, we find by illuminating the dilated pupil very obliquely from the side, and looking at it from the opposite side, that it presents a very faint grayish reflex from the anterior portion or surface of the lens, the most striking portion of which has the form of a star, the branches corresponding to the lens sectors. This phenomenon is due to the fact that the light is refracted by the lens capsule or by the lens fibers themselves.

With increasing age the consistency of the lens is altered, so that cataracts occurring late in life are harder than those in young persons. In persons past middle life we find that the reflex becomes more and more dense, so that in some elderly individuals the appearance of the pupil by ordinary illumination is similar to that of gray opacity of the lens, although the lens, as well as the patient's visual acuity, may be quite normal. In

addition to this general loss of transparency, age is attended with a great liability to distinct localized opacities of the crystalline lens.

The lens may be altered in consistency, in size, shape, and transparency. According to Priestley Smith, a cataractous lens is smaller and harder than a normal lens of the same age.

Etiology.—Age has a great influence upon the production of this condition, as it is most frequent here after fifty years of life, while in India the majority of patients with cataract come to operation at forty years or thereabouts. Mauthner operated successfully on a man one hundred and one years of age, the author on one of ninety, and Dr. Heinitch, of Spartanburg, S. C., on a man of one hundred and three (both eyes). Congenital cataract, however, is also encountered. The manner in which it is brought about, however, is not clear, but it is probably due to some disturbance of nutrition. Heredity is said to be a factor. Diseases such as diabetes, nephritis, gout, rheumatic diathesis, arterial disease, syphilis, etc., are also assigned as causes in certain cases. The artificial production of cataract in frogs by the administration of sugar has been reported by S. Weir Mitchell. (See "Diabetic Cataract.") Occupation seems to exert some influence in its production, as glass-blowers and those exposed to high degrees of light and heat are affected with uncommon frequency. Traumatism, directly or indirectly applied, is a cause in some cases. Toxic conditions, such as ergotism, have been followed by it. Ocular affections, such as iritis, iridocyclitis, ulcerative keratitis, uveitis, malignant myopia, choroiditis, glaucoma, retinitis, and detachment of the retina are particularly prone to induce cataract. Uncorrected ametropia is also a predisposing factor.

Symptoms.—Diminution of vision is perhaps the most prominent symptom. It varies according to the situation and character of the opacity. A peripheral cataract may be undetected for a long period, as it occasions very little disturbance of vision, while central opacities produce a marked diminution in visual acuity. Haziness and spots before the eyes are complained of by the patient, together with double vision and distortion of images. In the early stages, particularly in senile cataract, the swelling of the lens produces myopia and the patient is able for a while to

discard reading-glasses. This condition, however, is not permanent, and constitutes "second sight" of the laity.

Inflammatory symptoms may be present, but are not dependent upon the lens condition. The anterior chamber may be normal in depth, or it may be shallow or deep, according as the lens is swollen or contracted. The pupil may be normal, but is usually dilated on account of the obstruction the opaque lens offers to the passage of light to the eye-ground, thereby interfering with the pupillary reflex. The color of the pupillary area varies from a grayish hue to black, depending upon the maturity of the cataract, but at no time is the pupil filled by the normal bright-red reflex. Examination by means of the ophthalmoscope shows a black spot on a red ground in the early stages, but in the late stages the red ground is entirely effaced.

Varieties.—Cataract may be congenital or acquired. Congenital cataract may be due to faulty development or prenatal ocular inflammation, and includes anterior and posterior polar, lamellar, and occasionally complete cataract. All the other varieties are acquired by senile changes, injury, or adjacent inflammatory conditions.

According to the character of the cataract it may be considered as *primary* or *secondary*. Primary opacities arise independent of any obvious cause. Secondary cataracts are also called complicated, and follow ocular diseases and operations.

The consistency of an opaque lens also affords another classification, so that cataracts may be known as soft and hard. Soft cataracts are white in color and without any hard nucleus being encountered in persons under thirty years of age. Hard cataracts are distinguished by their hard nuclei and yellowish, sometimes darker tint, and occur later in life.

A division according to the extent of the opacity may be made, so that a cataract may be considered as complete or partial. Complete opacities involve the entire lens; partial cataracts are limited to one portion of that structure.

Cataracts may be capsular, lenticular, or capsulo-lenticular, according to the situation of the opacity.

The progress of the opacities serves to classify them as stationary and progressive. Stationary cataracts are subdivided into anterior polar, posterior polar, lamellar, and certain other con-

genital forms. Progressive cataracts include senile (cortical and nuclear), traumatic, and some congenital varieties. This form is further subdivided, according to their stage of ripeness, as immature, mature, and hypermature (Morgagnian).

Diagnosis.—Although failing vision is always accompanied by a more or less grayish condition of the lens, cataract is not necessarily present, and it is of greatest importance to recognize the true condition on account of the great differences in treatment. Oblique illumination serves to display opacities, striæ, and the maturity of the cataract. The condition of the anterior chamber can be readily observed, and the presence of swelling or contraction of the lens is easily determined thereby. In immature cataract the iris plane is pushed forward on account of the swollen fibers of the lens, and the anterior chamber is shallow; in mature cataract the iris plane is flat on account of the contracted fibers of the lens and the anterior chamber is deep. The candle test is also of value in this connection. Normally, a lighted candle moved before the eyes gives rise to three images: one on the anterior surface of the cornea, a second on the anterior surface of the lens, and a third inverted image on the posterior surface of the lens. In cataract the inverted image is no longer seen, and the image on the anterior surface of the lens also disappears if the capsule is involved. In complete cataract the corneal image alone is visible.

The candle-flame test was discovered by Sanson in 1836, and is one of the best means of distinguishing cataract from other conditions associated with blindness. It is an adaptation of Purkinje's test for accommodation. For its satisfactory performance the patient should be seated in a darkened room and the pupil dilated.

Treatment.—This consists in removal of the opaque lens. The manner in which this is performed varies according to the character of the cataract, and will be discussed under the descriptions of the different types of cataract.

SENILE CATARACT

SYNONYMS: *Simple Cataract; Gray Cataract.*

The term "senile cataract," sometimes known as "hard cataract," is justifiable when the disease occurs in persons of advanced

age—over forty-five years. It is met with most frequently between the fiftieth and seventieth years. The term "hard cataract" is applicable on account of the increasing rigidity and size of the nucleus, which accompanies age.

Symptoms.—Senile cataract is the most common as well as the most important form of cataract with which the ophthalmic surgeon has to deal. The patient complains of but one symptom, namely, a slowly increasing dimness of vision. This form of cataract develops very gradually; in fact, its development is occasionally so slow that sight may be lost in one eye before any impairment of vision is complained of by the patient. In a few cases the condition develops very quickly to a point where there is partial loss of vision, and then remains stationary for a time, or progresses very slowly. The opacity generally begins at the periphery of the lens, when it is known as *cortical cataract*, though it not infrequently originates at the center of the lens, in which position it is known as *central* or *nuclear* cataract; or, it may develop in both these positions simultaneously.

It is rarely observed in individuals under fifty years of age, and the time required to reach maturity, or involve the whole body of the lens, varies greatly after its inception, the process sometimes extending over a period of years—the average time being about three years. In those cases where the opacity is not symmetrically distributed throughout the lens, the acuity of vision may vary, being perhaps better in a feeble light in one case, and in another better in a strong light. The grayish or dulled translucency of the capsule observed in old people, and a purely physiologic phenomenon, is sometimes very difficult to differentiate from incipient cataract. By oblique or focal illumination these two conditions may look alike, and a correct diagnosis cannot be made by this means, but on using transmitted light at a distance of several inches the difference can easily be noted.

In most cases the impairment of vision is not so great as to interfere with the counting of fingers held a few inches from the eye, but in some instances movement of the hand cannot be detected. In all cases of senile cataract light perception is retained when not complicated with intra-ocular disease.

Impairment of vision in the first stages of cataract may be due to refractive changes, rather than to the lessening of the

translucency of the lens. There may, for example, be an increased refraction at the nucleus, causing myopia when the pupil is contracted, or negative aberration when the pupil is dilated. In other eyes irregular astigmatism is produced by the refractive change, giving rise to sectors of light and shadow very closely resembling cortical opacities of the lens.

Progressive cataracts usually pass through the following stages:

The *incipient stage*, in which there is more or less opacity, although some portions of the pupil still remain clear enough to give imperfect though useful vision. The beginning of the opacity is marked by streaks that extend from the periphery to the center of the lens and resemble the spokes of a wheel. By oblique illumination these streaks present a grayish appearance, but when viewed by means of the ophthalmoscope they appear black. The portions of the lens between these striæ are transparent. Not infrequently the opacities begin as dots or clouds, coalescing as maturity is reached. These may form at the cortex or in the nucleus and gradually extend over the entire lens—the *stage of swelling* or intumescence, in which the lens becomes swollen by inhibition of fluid. The iris, in consequence of this swelling, is pushed forward, making the anterior chamber of the eye more or less shallow. The opacity has become more marked than in the first stage, though it is still incomplete. The stellate appearance of the lens is more distinct, and the cataract appears bluish-white in color. The superficial portion of the lens is still transparent, so that upon oblique illumination the iris casts a shadow upon the lens. Myopia makes its appearance in this stage, so that the patient is able to dispense with reading-glasses for a time.

Diagnosis of Maturity.—The *stage of maturity* is that in which the lens is completely translucent, and, unlike the second stage, is not swollen, but has returned to its original size. The anterior chamber is of normal depth. It is during this stage that the operation of extraction is productive of best results.

The following test is employed to determine whether or not a cataract is "ripe." The eye is obliquely illuminated; if the iris throws no shadow on the lens substance behind it, or if no shining sectors are seen, and there is no transmission of a reddish glare, the cataract is mature. If an area of blackness is clearly visible

behind the iris, on the inner or outer side, it indicates that the lens is not mature at its periphery.

Another indication of the maturity of a cataract is found in the peculiar mother-of-pearl luster of the surface of the lens under oblique illumination. When the red fundus reflex cannot be seen with the ophthalmoscope through a dilated pupil, we have further evidence of its maturity. If the patient cannot count fingers at arm's length, when seated with his back to a window, we may assume that the cataract is mature.

Fig. 138.—Mature Senile Cataract.

The reason operation is of most benefit in this stage is on account of the ease with which the opaque lens can be separated from its capsule, thus lessening the liability to after-cataract from remnants of the cortex left behind.

The *last stage* is that of hypermaturity or overripeness. In this stage we find the lens shrunken, hardened, occasionally calcareous, and the lens capsule thickened and tough, and often thrown into ridges or folds.

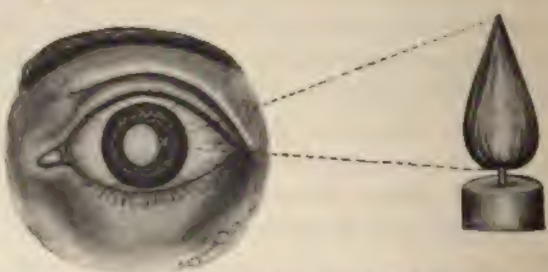

Fig. 139.—Shadow of the Iris seen from in Front (Immature Cataract).

The crescentic shadow (X) appears at the side of the pupillary margin that is turned toward the source of light.

In hypermature or "overripe" cataracts the cortical portions undergo fatty degeneration and liquefaction. The nucleus still preserves its amber cast, and may be displaced to the lower part of the capsule. This form of cataract, which is usually found in patients over sixty-five years of age, and in whom the cataract has existed for from five to ten years, is known as a *Morgagnian cataract.*

Treatment.—If a positive diagnosis of cataract has been made, the question as to whether or not we should frankly tell the patient that he has a cataract, or simply make a diagnosis of "incipient lenticular opacity," depends upon the judgment of the physician and the character of the patient; each case must be decided for itself. It is justifiable to partially conceal the truth from the patient by making the latter diagnosis if only one eye is affected, the other remaining normal, since it will be a matter of great comfort to the suffering individual. (The friends of the patient should, however, be informed as to the true condition of affairs.) To wait an indefinite period of time for the ripening of a cataract in each eye is a source of extreme mental distress.

Amethyst-tinted glasses will occasionally afford a measure of relief to the patient. Atropin should not be used for this purpose, except in rare cases; if it is, and in a few cases it is justifiable, the patient should be kept under surveillance by the ophthalmic surgeon. Both convex and concave spherical lenses may be tried.

It must be borne in mind that we must ascertain whether the retina and optic nerve are in normal condition before we advise an operation for cataract. The patient's light-projection should be tested, as well as the reaction of the pupils to light.

A satisfactory test for light-projection may be made with a lighted candle in a dark room. The patient is asked to keep his eye fixed in a certain direction, and the candle is then moved about in different quadrants of the visual field. If the patient locates the source of light promptly, we may assume that the retina is in good condition, and that, if no inflammatory reaction follows the operation, a favorable result may be anticipated.

To ascertain whether the irides respond promptly to light, both eyes are covered by the hands, thus placing them, as it were, in a darkened chamber. The pupils should, of course, dilate under this condition. One hand is then suddenly removed from the cataractous eye; if the retina appreciates light, the pupil suddenly contracts.

Artificial Ripening of Cataract.—Methods designed to hasten ripening of the cataract are not infrequently employed. In some cases this result has been achieved by massage of the lens. Indirect massage is performed by tapping the anterior chamber of the eye, drawing off the aqueous substance so that the lens falls

against the cornea, and then stroking the cornea with a corneal spatula within the area of the pupil, which has been previously dilated with atropin. Or, an iridectomy may be performed and the cornea, over the area of the pupil and the coloboma of the iris, similarly massaged. Direct massage is performed either with or without an iridectomy, by introducing a spatula into the anterior chamber of the eye and then stroking the anterior lens capsule. Puncture of the lens may be followed by swelling of the lens and glaucomatous symptoms, and iritis may supervene.

Operations should not be performed on both eyes at the same time, even though both cataracts are mature. Some surgeons will not remove a ripe cataract if the vision of the other eye is perfect, or nearly perfect, because the difference in refraction renders binocular vision impossible, and the patient is not so well satisfied with his sight after the operation as before. In the author's experience, however, matters have been somewhat different; although binocular vision may not have been obtained, yet the enlargement of the visual field amply compensates for this loss.

The special difficulties that the ophthalmic surgeon experiences in removing a cataract before maturity are that parts of the cortex, clear at the time of operation, will remain adherent to the capsule of the lens, and later undergo the process of opacification, thus again impairing vision until absorbed or until removed by an operation for capsular cataract.

Some operators, however, operate on immature cataracts, washing out the tenacious material with a syringe. This is advisable in patients over seventy years of age, since the lens is hard enough to be extracted without leaving any cortical mass behind. If a choice between operating on an immature cataract or artificially hastening maturity becomes necessary, the former would seem preferable.

It should always be known with certainty that a cataract is ripe before an operation is performed. If an unripe cataract were removed, a portion of the lens would almost inevitably be left intact, and in the course of time this would probably become opaque and necessitate a second operation.

The best operation for cataracts is extraction of the opaque lens preceded by an iridectomy. The details of the entire operation will be described in another portion of this chapter.

Prognosis.—There is a great want of uniformity between the percentages of cures given by the different operators. It may be said, generally, that if the patient is in good condition, and the tissues are as elastic as is consistent with the age of the patient and the light perception is clear and decisive, a good result is to be expected.

Spontaneous disappearance of lenticular opacities does occur, but is extremely rare. For literature upon this subject, see paper by W. L. Pyle, *Journal of the American Medical Association*, October 18, 1902.

BLACK CATARACT

(*Cataracta Nigra*)

Opacification of the crystalline lens that assumes a brown-black color is a comparatively rare condition. Its density is greater than in other forms of cataract, and the cause of this peculiar coloration has given rise to considerable conjecture. There are instances when the crystalline lens becomes infiltrated and filled with blood. In these cases the blood pigment has been demonstrated by the spectroscope. In the true black cataract, according to Parsons, the color is a dark mahogany brown, probably an exaggeration of the normal amber color, but neither chemical nor spectroscopic tests reveal evidences of blood pigment. Müller attributed it to melanosis; Langenbeck considered it as due to the presence of manganese, while Lawrence and Guthrie supposed it to be produced by the oxid of iron in the lens. Some of the more recent authorities believe it to be derived from the blood pigment.

The existence of black cataract has been much disputed until within comparatively recent years. Dupuyten had never seen one, and denied it as a possibility. Desmarres, Pellier, Wenzel (senior), Graefe (senior), and Lusardi, however, described accurately cases under their own observation that excluded any doubt as to its existence. Among ophthalmic surgeons of the present day it is subjected to but passing mention on account of its rare occurrence. In my own experience I have encountered and extracted eight "black cataracts." In one of these cases there was a dark nucleus embedded in the semitranslucent part of the lens, while

beyond was a yellow band. The diagnosis of black cataract can only be made by oblique illumination.

The late Dr. Swan M. Burnett has given a capital description of this form of cataract, which may be read with interest.

AFTER-CATARACT

SYNONYMS: *Secondary or Membranous Cataract; Opaque Capsule; Secondary Pupillary Membrane.*

Definition.—A condition characterized by an opacity of the lens capsule, either posterior or anterior, which exists or develops after removal of the crystalline lens.

In performing a cataract operation either a part of or the whole lens capsule is allowed to remain in the eye. A number of operations have been devised for the purpose of removing the entire capsule as well, but the difficulty and the risk attending these operations bear no proportion to the advantages that are secured.

The after-cataract is produced as follows:

After an operation for the removal of cataract has been performed, the transparency of the lens capsule is altered, and the adherent cortex at first swells and becomes more or less opaque. The capsule retracts and folds upon itself. In a short time the opacity of the capsule disappears and the cortex likewise becomes absorbed, the vision improving greatly in a week or ten days after the removal of the cataract. Later the capsule undergoes a process of thickening, due to proliferation of the epithelial cells on its under surface, so that the vision obtained as a result of the operation again diminishes to a greater or less extent. Sometimes the capsule after the operation becomes shriveled or puckered, thus producing a disturbance of vision nearly as troublesome as an opacity. In other cases, as after the extraction of an immature cataract, a portion of the cortex may be left behind even by the most careful and experienced surgeon, and this gives rise to an opacity that may entirely occlude the pupil. Absorption takes place, but often requires months for its completion. A second needling operation or a capsulotomy is a more certain way of removing it.

The diagnosis is easily made by oblique illumination or by

means of the ophthalmoscope. The pupillary area is partially or completely filled with an opaque material resembling the original cataract, but which is less extensive.

The second operation should be deferred until after all signs of irritation from the previous one have disappeared. This is usually from about six or seven weeks to three months. After-cataract can be removed by needling or capsulotomy.

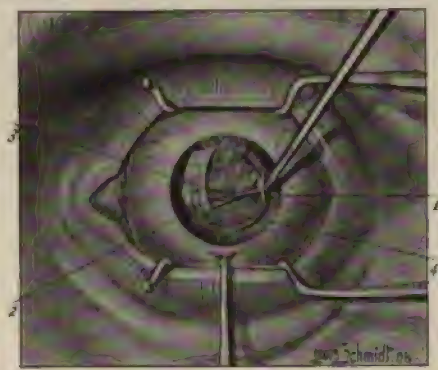

FIG. 140.—DE WECKER'S OPERATION FOR SECONDARY CATARACT.

1. Corneal incision. 2. Anterior blade of scissors, in anterior chamber. 3. Posterior blade of scissors behind capsule. 4. Capsule.

Capsulotomy.—The author's favorite method for operating on posterior recurrent capsular cataract is as follows:

When the posterior capsule remains intact and obscures central vision, a secondary operation—capsulotomy—must be performed. The author prefers making an incision in the cornea with a broad needle, entering the capsule in the vertical direction (Fig. 140[1]). De Wecker scissors are then introduced through the corneal opening, and the blades separated, one blade passing behind the capsule (Fig. 140[3]), the other horizontally in front (Fig. 140[2]). With one snip the capsule (Fig. 140[4]) is cut in two. This operation is most successful, giving a wide clear pupil.

Ziegler's Capsulotomy by the V-shaped Method.—This is described by the author himself as follows: The application of the V-shaped method to capsulotomy shows an even greater field of usefulness, as this method is par excellence the best way of incising a delicate secondary capsular cataract. This should be done under artificial illumination. The pupil should be dilated, as the area of incision is necessarily smaller than in iridotomy, and unnecessary wounding of the iris should be avoided. The proposed capsular opening must be so calculated as to fall within the area of the undilated pupil, or partly within the coloboma if an iridectomy has been previously performed.

which he so successfully operated. Sir William Bowman, many years afterwards, modified the shape of this needle by placing a shoulder on it, and this Bowman's stop-needle, as it is now known, is almost universally used by ophthalmic surgeons.

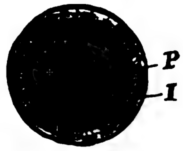

FIG. 145.—LAMELLAR CATARACT SEEN BY REFLECTED LIGHT. Magnified 3 × 2.

The iris, *I*, has retracted under atropin. The opacity forming the lamellar cataract is denser at the margin than at the center. The riders are depicted in the upper half, but are left out below to show how a lamellar cataract looks without them. Between the margin of the opacity and the margin of the pupil, *P*, is a black interspace corresponding to the transparent periphery of the lens.

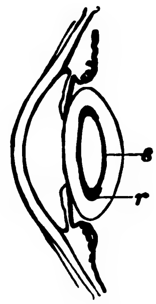

FIG. 146.—LAMELLAR CATARACT IN CROSS SECTION. SCHEMATIC. Magnified 2 × 1.

The layers, *s*, placed between nucleus and cortex, are opaque, but the adjacent layer is so only in the equatorial region, *r*, so that riders are formed.

The only complication which may arise in the needle operation is the too rapid swelling of the lens, which, by exerting pressure on the ciliary body, may cause cyclitis. When this occurs, it may be necessary to remove part of the soft lens by Teale's method — namely, making an incision into the anterior chamber through the upper third of the cornea, and sucking out part of the lens substance with a specially devised instrument or by simple pressure.

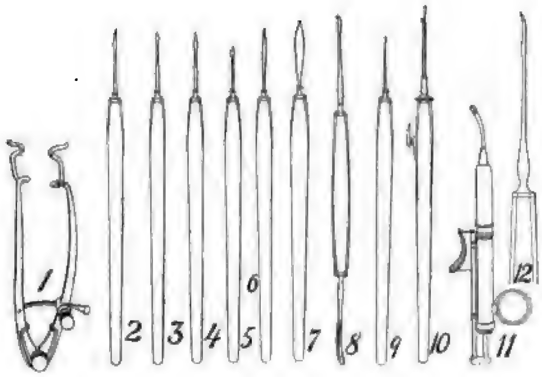

FIG. 147.—INSTRUMENTS FOR OPERATIONS ON SECONDARY AND SOFT CATARACTS.

1. Clark speculum 2. Cataract needle with sickle-shaped edge 3. Bowman's stop needle. 4 Same; long cutting edge. 5 Dalrymple knife. 6 Saunders' cataract needle. 7. Broad needle 8. Boyer's cystitome. 9 Jaeger's hook. 10. Juengken's hook. 11. Bowman's curette suction for soft cataract. 12. Galezowsky's knife.

The after-treatment is the constant application of

iced cotton pledgets saturated in 1-2,000 bichlorid-of-mercury solution, which are to be changed every half hour. The iris should be kept well dilated, and the ciliary body placed at rest by the instillation of 1 drop of atropin (1-grain to 3-dram solution) three times daily. Gray powder (mercury and chalk) should also be administered in 1-grain doses three times daily for one week. If violent inflammatory reaction takes place, the mercury should be increased to its physiologic limit.

ZONULAR CATARACT

(Lamellar Cataract; Perinuclear Cataract)

This form of cataract is usually congenital, though not infrequently it develops in early infancy. It is generally bilateral, though rare cases have been observed in which one eye only was affected. Since vision is not materially impaired by it, it often escapes detection until a much later period in life. On dilating the pupil with atropin, an opacity of the lens is observed. In cases of congenital origin this opacity is thought to be produced by a temporary interruption of nutrition during the formation of the lens.

Etiology.—In those cases in which the condition develops during infancy a history of convulsions can usually be obtained, and the various landmarks of rachitis may be detected upon careful examination. Burton Chance (*Ophthalmic Record*, December, 1908), of Philadelphia, reports a case of pyramido-zonular cataract in an unmarried woman aged twenty-four, of fair general health, who exhibited no signs of rachitis. Heredity is an important factor in the etiology of this form of cataract. Syphilis may sometimes be the underlying cause, but there are as yet few if any accurate clinical data to substantiate this.

Symptoms.—The opacity is situated between the nucleus and periphery, the remaining portion of the lens being normal in appearance, and through it the reflex from the eye-ground is often observed.

On examining the eye by oblique illumination it appears of uniformly light-gray color, sharply defined, and surrounded by a more or less broad margin of transparent cortical substance.

If the opacity is not dense, vision may be relatively good, so

that large print can be read with ease. Sight may generally be improved by dilating the pupil with a weak solution of atropin, which permits the rays from the object to pass through the clear marginal portion of the lens. According to Lawford, the anatomical change is a degenerative one.

Microscopical examination of these cataracts has been made by Deutschmann, Schirmer, Lawford, Treacher Collins, and others. The changes essentially consist of disturbances in the structure of the lenticular fibers by vacuoles.

Individuals suffering from this variety of cataract are quite often supposed to be myopic, as they hold small objects very close to the eye in order to gain larger retinal impressions. In point of fact, the majority of these patients are hyperopic, since the interruption of development of the lens is frequently accompanied by interruption in the development of the eyeball, and a small eyeball is hyperopic. Nystagmus is a common symptom.

Zonular cataract is usually stationary. If vision is not greatly improved by dilating the pupil, some improvement is to be hoped for by performing an *iridectomy*. Discission (*q. v.*) should be performed at once unless there is evidence of calcareous deposit in the lens, in which case an iridectomy, or the complete removal of the lens, is necessary.

DIABETIC CATARACT

This form of cataract, which is associated with diabetes (6 per cent of diabetic patients have cataract) is usually of the soft variety and matures slowly; the author has observed cases, however, in which maturity was reached in from three to six months. In about 1 per cent of cataract cases sugar has been present in the urine. The blood in diabetic patients is below normal, the percentage of solids being greater than under normal conditions. This gives rise to an exosmosis of the watery constituents of the lens, a loss of transparency in its fibers, and a deposition of calcareous and other salts. Neither the presence of sugar in the eye nor the abstraction of water from the lens have as yet demonstrated the true cause of diabetic cataract. In the case of the first theory, experiments have shown that it requires by far more sugar to produce an experimental cataract than is found in the aqueous in cases of diabetes. The second theory can be rejected

for two reasons: (1) In cases of cholera the lens may remain perfectly clear even when there is enormous abstraction of water from the body, and (2) v. Michel has shown that experimental abstraction of water from the lens will induce no permanent opacity if the lens is again dried or placed in glycerin.

The microscopical changes found in diabetic cataract are essentially those of the cortical variety.

The diabetic lens is uniformly opaque. The cataractous condition usually does not appear until a later stage of diabetes, when the patient is greatly enfeebled and much broken down in health; yet it may occur in well-nourished individuals.

Diabetic cataract is most frequently met with about middle age, and is usually bilateral. The perception of light and the condition of the visual field should always be very carefully tested in this variety of cataract, as affections of the retina and optic nerve not infrequently occur in the course of diabetes, and if such diseases coexist with the cataract, an operation may be of no avail.

The method of extraction is optional with the surgeon; the author performs the simple operation—i. e., without iridectomy. The author's method consists in making a large flap incision in the cornea, and he has found by adopting this method that the eye recovers from the operation almost as well as in patients who are not suffering with the disease.

Uhthoff reported a series of 115 cataract operations in diabetics, not one of which was totally lost. Two obtained only a minimum amount of vision. Good vision was obtained in 68 per cent, useful vision in 18 per cent, poor vision in 14 per cent, total blindness, no perception of light, in 0. These results were just as good as those obtained after cataract extractions in the nondiabetic.

ANTERIOR AND POSTERIOR POLAR CATARACTS

This variety of cataract is due to some antecedent inflammation of the eye, and may manifest itself at the lens anteriorly or posteriorly. Unless opacity of the lens itself exists, the term "cataract" is of course not an accurate one, but according to the usual nomenclature we still recognize the terms anterior and posterior polar cataract, even if persistent fetal structures cause the opacity.

Anterior Polar or Capsular Cataract (*Pyramidal Cataract*).—This form of cataract may be of congenital origin, though these cases are rare. It is usually acquired in childhood, in the following manner: In perforating ulcer of the cornea (such, for example, as is sometimes met with in ophthalmia neonatorum), the anterior chamber of the eye is emptied, the lens is pushed forward and comes in immediate contact with the inflamed cornea, the perforation becoming closed by lymph deposition. When the lens resumes its normal position, as a result of the refilling of the anterior chamber, it carries back some of this exudative material, which adheres to the lens as a cone-shaped body, about the size of a millet seed. The author has also observed this condition following cases of ophthalmia neonatorum, where there has been great edema of the lids, and consequently a great deal of pressure on the cornea, irritating the anterior capsule of the lens or possibly Descemet's membrane, and giving rise to this white deposit without perforation of the cornea.

The condition is scarcely ever serious enough to require an operation, unless the opacity is large enough to fill the pupillary space, in which case an iridectomy should be suggested.

Posterior Polar Cataract.—This form of cataract may either be congenital or secondary to chronic iridochoroiditis, retinitis, high myopia, tumors, and sometimes absolute glaucoma. In the latter complications the opacity is sometimes star-shaped in appearance. In the former case it may be due to vestigial remains of the hyaloid artery at its lenticular attachment.

Posterior polar cataract can only be discovered by the careful use of the ophthalmoscope, with which it appears as a small black spot against the red fundus reflex.

A larger area of opacity, often assuming the shape of a radiating figure, constitutes another variety; still other forms resemble the rings of Saturn. In the event of coexistence of retinitis or choroiditis the prognosis is of course materially affected.

It frequently remains stationary for a long period and then progresses toward complete cataract.

Treatment is rarely called for in this variety of cataract. If, however, an operation becomes necessary, an artificial pupil may give good results; and if this measure fails, discission will probably be indicated.

DISSEMINATED DOT CATARACT

C. Wray [1] describes a form of cataract "characterized by the presence in the lens structure of numerous very thin, small, whitish or bluish punctiform deposits, nearly always less than 0.5 mm. in diameter." These dots are most numerous toward the equator, and are situated so far toward the periphery of the lens that they are apt to be overlooked unless a very careful examination is made under focal illumination. The author recently examined a patient at the Medico-Chirurgical Hospital with these characteristic dots and spots in one eye only.

In this form of cataract no active interference is necessary.

TRAUMATIC CATARACT

Traumatic cataract is produced by an injury to the lens, the most common cause being the entrance of a foreign body through the cornea which ruptures the lens, although cases have been reported in which the lens was dislocated or even ruptured without any wound of the coats of the eyeball.

It is only in very rare cases that a foreign body enters the lens substance without producing cataract. The mere pricking of the lens with the point of a knife, as may accidentally occur in performing an iridectomy or paracentesis, is sufficient to produce cataract, and there is no question that the condition has frequently been produced in this way.

If the capsule is perforated by the entrance of a foreign body, the aqueous is admitted to the substance of the lens, which may rapidly become opaque. Should, however, the perforation be rather small and superficial, the attendant danger may be very slight, since there is a possibility that the lips or edges of the minute wound will unite, in which case, if an opacity does form, it will not be extensive. On the other hand, if the wound be larger and deeper, a greater amount of aqueous is admitted into the lens, which consequently becomes swollen, and, by exerting pressure on the iris and ciliary body, may set up an inflammation involving these bodies. The inflammation may be either

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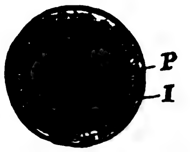
[1] *Trans. of the Ophthalmological Soc. of the United Kingdom*, vol. xii, 1892, p. 109.

which he so successfully operated. Sir William Bowman, many years afterwards, modified the shape of this needle by placing a shoulder on it, and this Bowman's stop-needle, as it is now known, is almost universally used by ophthalmic surgeons.



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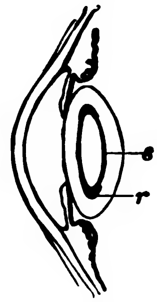

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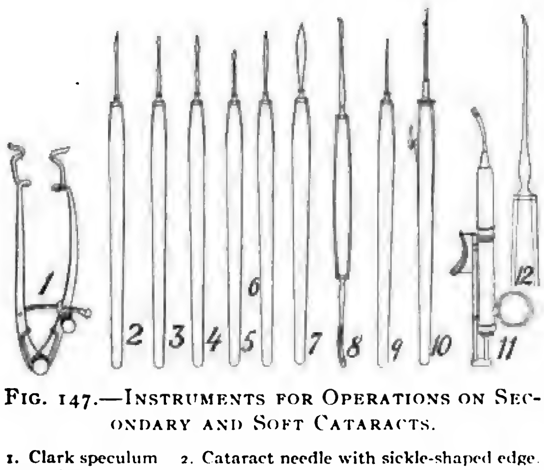

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ZONULAR CATARACT

(*Lamellar Cataract; Perinuclear Cataract*)

This form of cataract is usually congenital, though not infrequently it develops in early infancy. It is generally bilateral, though rare cases have been observed in which one eye only was affected. Since vision is not materially impaired by it, it often escapes detection until a much later period in life. On dilating the pupil with atropin, an opacity of the lens is observed. In cases of congenital origin this opacity is thought to be produced by a temporary interruption of nutrition during the formation of the lens.

Etiology.—In those cases in which the condition develops during infancy a history of convulsions can usually be obtained, and the various landmarks of rachitis may be detected upon careful examination. Burton Chance (*Ophthalmic Record*, December, 1908), of Philadelphia, reports a case of pyramido-zonular cataract in an unmarried woman aged twenty-four, of fair general health, who exhibited no signs of rachitis. Heredity is an important factor in the etiology of this form of cataract. Syphilis may sometimes be the underlying cause, but there are as yet few if any accurate clinical data to substantiate this.

Symptoms.—The opacity is situated between the nucleus and periphery, the remaining portion of the lens being normal in appearance, and through it the reflex from the eye-ground is often observed.

On examining the eye by oblique illumination it appears of uniformly light-gray color, sharply defined, and surrounded by a more or less broad margin of transparent cortical substance.

If the opacity is not dense, vision may be relatively good, so

that large print can be read with ease. Sight may generally be improved by dilating the pupil with a weak solution of atropin, which permits the rays from the object to pass through the clear marginal portion of the lens. According to Lawford, the anatomical change is a degenerative one.

Microscopical examination of these cataracts has been made by Deutschmann, Schirmer, Lawford, Treacher Collins, and others. The changes essentially consist of disturbances in the structure of the lenticular fibers by vacuoles.

Individuals suffering from this variety of cataract are quite often supposed to be myopic, as they hold small objects very close to the eye in order to gain larger retinal impressions. In point of fact, the majority of these patients are hyperopic, since the interruption of development of the lens is frequently accompanied by interruption in the development of the eyeball, and a small eyeball is hyperopic. Nystagmus is a common symptom.

Zonular cataract is usually stationary. If vision is not greatly improved by dilating the pupil, some improvement is to be hoped for by performing an *iridectomy*. Discission (*q. v.*) should be performed at once unless there is evidence of calcareous deposit in the lens, in which case an iridectomy, or the complete removal of the lens, is necessary.

DIABETIC CATARACT

This form of cataract, which is associated with diabetes (6 per cent of diabetic patients have cataract) is usually of the soft variety and matures slowly; the author has observed cases, however, in which maturity was reached in from three to six months. In about 1 per cent of cataract cases sugar has been present in the urine. The blood in diabetic patients is below normal, the percentage of solids being greater than under normal conditions. This gives rise to an exosmosis of the watery constituents of the lens, a loss of transparency in its fibers, and a deposition of calcareous and other salts. Neither the presence of sugar in the eye nor the abstraction of water from the lens have as yet demonstrated the true cause of diabetic cataract. In the case of the first theory, experiments have shown that it requires by far more sugar to produce an experimental cataract than is found in the aqueous in cases of diabetes. The second theory can be rejected

for two reasons: (1) In cases of cholera the lens may remain perfectly clear even when there is enormous abstraction of water from the body, and (2) v. Michel has shown that experimental abstraction of water from the lens will induce no permanent opacity if the lens is again dried or placed in glycerin.

The microscopical changes found in diabetic cataract are essentially those of the cortical variety.

The diabetic lens is uniformly opaque. The cataractous condition usually does not appear until a later stage of diabetes, when the patient is greatly enfeebled and much broken down in health; yet it may occur in well-nourished individuals.

Diabetic cataract is most frequently met with about middle age, and is usually bilateral. The perception of light and the condition of the visual field should always be very carefully tested in this variety of cataract, as affections of the retina and optic nerve not infrequently occur in the course of diabetes, and if such diseases coexist with the cataract, an operation may be of no avail.

The method of extraction is optional with the surgeon; the author performs the simple operation—i. e., without iridectomy. The author's method consists in making a large flap incision in the cornea, and he has found by adopting this method that the eye recovers from the operation almost as well as in patients who are not suffering with the disease.

Uhthoff reported a series of 115 cataract operations in diabetics, not one of which was totally lost. Two obtained only a minimum amount of vision. Good vision was obtained in 68 per cent, useful vision in 18 per cent, poor vision in 14 per cent, total blindness, no perception of light, in 0. These results were just as good as those obtained after cataract extractions in the nondiabetic.

ANTERIOR AND POSTERIOR POLAR CATARACTS

This variety of cataract is due to some antecedent inflammation of the eye, and may manifest itself at the lens anteriorly or posteriorly. Unless opacity of the lens itself exists, the term "cataract" is of course not an accurate one, but according to the usual nomenclature we still recognize the terms anterior and posterior polar cataract, even if persistent fetal structures cause the opacity.

Anterior Polar or Capsular Cataract (*Pyramidal Cataract*).—This form of cataract may be of congenital origin, though these cases are rare. It is usually acquired in childhood, in the following manner: In perforating ulcer of the cornea (such, for example, as is sometimes met with in ophthalmia neonatorum), the anterior chamber of the eye is emptied, the lens is pushed forward and comes in immediate contact with the inflamed cornea, the perforation becoming closed by lymph deposition. When the lens resumes its normal position, as a result of the refilling of the anterior chamber, it carries back some of this exudative material, which adheres to the lens as a cone-shaped body, about the size of a millet seed. The author has also observed this condition following cases of ophthalmia neonatorum, where there has been great edema of the lids, and consequently a great deal of pressure on the cornea, irritating the anterior capsule of the lens or possibly Descemet's membrane, and giving rise to this white deposit without perforation of the cornea.

The condition is scarcely ever serious enough to require an operation, unless the opacity is large enough to fill the pupillary space, in which case an iridectomy should be suggested.

Posterior Polar Cataract.—This form of cataract may either be congenital or secondary to chronic iridochoroiditis, retinitis, high myopia, tumors, and sometimes absolute glaucoma. In the latter complications the opacity is sometimes star-shaped in appearance. In the former case it may be due to vestigial remains of the hyaloid artery at its lenticular attachment.

Posterior polar cataract can only be discovered by the careful use of the ophthalmoscope, with which it appears as a small black spot against the red fundus reflex.

A larger area of opacity, often assuming the shape of a radiating figure, constitutes another variety; still other forms resemble the rings of Saturn. In the event of coexistence of retinitis or choroiditis the prognosis is of course materially affected.

It frequently remains stationary for a long period and then progresses toward complete cataract.

Treatment is rarely called for in this variety of cataract. If, however, an operation becomes necessary, an artificial pupil may give good results; and if this measure fails, discission will probably be indicated.

DISSEMINATED DOT CATARACT

C. Wray [1] describes a form of cataract " characterized by the presence in the lens structure of numerous very thin, small, whitish or bluish punctiform deposits, nearly always less than 0.5 mm. in diameter." These dots are most numerous toward the equator, and are situated so far toward the periphery of the lens that they are apt to be overlooked unless a very careful examination is made under focal illumination. The author recently examined a patient at the Medico-Chirurgical Hospital with these characteristic dots and spots in one eye only.

In this form of cataract no active interference is necessary.

TRAUMATIC CATARACT

Traumatic cataract is produced by an injury to the lens, the most common cause being the entrance of a foreign body through the cornea which ruptures the lens, although cases have been reported in which the lens was dislocated or even ruptured without any wound of the coats of the eyeball.

It is only in very rare cases that a foreign body enters the lens substance without producing cataract. The mere pricking of the lens with the point of a knife, as may accidentally occur in performing an iridectomy or paracentesis, is sufficient to produce cataract, and there is no question that the condition has frequently been produced in this way.

If the capsule is perforated by the entrance of a foreign body, the aqueous is admitted to the substance of the lens, which may rapidly become opaque. Should, however, the perforation be rather small and superficial, the attendant danger may be very slight, since there is a possibility that the lips or edges of the minute wound will unite, in which case, if an opacity does form, it will not be extensive. On the other hand, if the wound be larger and deeper, a greater amount of aqueous is admitted into the lens, which consequently becomes swollen, and, by exerting pressure on the iris and ciliary body, may set up an inflammation involving these bodies. The inflammation may be either

[1] *Trans. of the Ophthalmological Soc. of the United Kingdom*, vol. xii, 1892, p. 109.

serous or purulent, depending upon the extent and nature of the irritation.

The lens usually becomes more rapidly opaque in younger than in elderly individuals. Cases have been observed in which the entire lens became completely cataractous in the course of a few days after the injury.

In cases of injury to the lens, the intra-ocular tension, the condition of the sight, and of the visual field should be frequently examined, so that if symptoms of glaucomatous or other complications make their appearance they may at once be detected and the necessary treatment instituted. There is a remote possibility of sympathetic ophthalmitis, and this should always be borne in mind.

Traumatic cataract is occasionally the result of a simple contusion of the eye, without any laceration of its outer or external coats. A blow upon the eye, or over the head, from a fist or some blunt body (a piece of wood, whip, brick, etc.), may give rise to this form of cataract.

This is evidently due to a laceration of a zonule of Zinn or the suspensory ligament, which prevents the normal nourishment of the lens. The laceration of the lens capsule depends particularly upon the character of the blow received, and especially upon its force.

Treatment.—The eye should be placed at absolute rest by the instillation of atropin. The presence of a foreign body will require treatment suggested under foreign bodies in the eyeball. Extraction of the foreign body is always indicated. The occurrence of iritis will necessitate extraction of the lens as soon as possible. Purulent inflammation may follow, leading to destruction of the eyeball and requiring enucleation. When there is rapid swelling of the lens with pain and ciliary congestion, some of the lens substance should be evacuated through a corneal incision.

CATARACT OPERATIONS

All patients presenting themselves for a cataract operation should be carefully interrogated as to their general habits and family history, and a careful urinalysis should be made.

The patient's diet should be largely vegetable, meat being excluded, and this regimen should be insisted upon for several weeks preceding the operation. One week before the operation the patient should be placed on mixed treatment, mercury and potassium or sodium iodid, and particular attention paid to bathing both eyes with a boric-acid solution containing sulphocarbolate of zinc. It is of value to know the blood-pressure. Too high pressure causes hemorrhages at time of operation, and even causing secondary hemorrhage.

The nasal cavities should be subjected to a most careful examination, and if any catarrhal affections are detected, it is of paramount importance that they receive proper attention before the operation is performed.

The day before the operation the patient is given a warm bath, saline purgatives, kept in bed, and his face washed with castile soap and water. Two hours before the operation the skin around the eye to be operated on is carefully washed with castile soap; following this by placing eye pads saturated with a 1–2,000 solution of corrosive sublimate over both eyes. It is not possible to have strictly an aseptic operation on the eye, but one can lessen the risk of infection by following out certain rules of irrigation so as to reduce the number of organisms, and inhibit the power of those which may escape, to such an extent that infection of the wound becomes almost nil. The instruments and bandages are, of course, always carefully sterilized. (See Chapter XXIV.) The eye to be operated upon should be thoroughly anesthetized by means of a 5-per-cent solution of cocain instilled into the eye.

The author prescribes 1 to 2 grains of mercury with chalk three times daily for a week or ten days before an operation. This preliminary treatment is of great value in lessening the risk of secondary complications.

In childhood, or in adults up to thirty years of age, the needle operation is performed. After this age a corneal incision should be made. Extreme age does not seem to contraindicate an operation. The author has successfully removed a cataract from a patient ninety years old; Professor Mauthner operated successfully on a patient one hundred and one years old.

EXTRACTION THROUGH A CORNEAL INCISION

The operation most commonly in use for cataract at the present time is extraction through a corneal incision, with or without an iridectomy.

Preparation of the Eye.—At the time of the operation the eyelids and brows are carefully cleansed with neutral soap [1] and warm sterile water. The conjunctival sac is carefully irrigated with (1) 1–5,000 solution of mercuric iodid,[2] (2) followed with a normal saline solution (1 to 2 ounces) slightly warmed. These solutions are applied by specially devised Undine bottles containing 5 to 10 ounces of the solution. A veil of sterilized gauze with an opening exposing the eye to be operated upon, is spread over the face of the patient. The eye is anesthetized by making several instillations of a 5-per-cent cocain solution at short intervals before the operation, say five minutes. The pupil of the eye to be operated upon should always be dilated one hour before the operation is performed. The author prefers atropin (2 drops of 1 grain to a 3-dram solution) for this purpose.

FIG. 148.—THE PROPER WAY OF HOLDING A CATARACT KNIFE. THE THIRD FINGER IS LOCKED.

Anesthesia.—General anesthesia should never be induced unless absolutely indicated; and if it must be brought about, chloroform is preferable to ether.

The Position of the Surgeon.—If the right eye is being operated on, the surgeon stands behind the patient's head; if it is the left eye, and the surgeon is not ambidextrous, he must stand in front and to the right of the patient.

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[1] For formula of neutral soap, see p. 724.

[2] ℞ Hydrargyri iodidi rubri.............. gr. 2.9; 0.19
Potassii iodidi....................... gr. 2.5; 0.15
Aqua destillatæ.................. fl ℥ 32; 960.0

If ambidextrous, the surgeon stands in front of and to the right of the patient.

An eye speculum is inserted and the conjunctiva is seized with the fixation forceps at the corneoscleral margin opposite the point of incision and below the horizontal plane of the cornea.

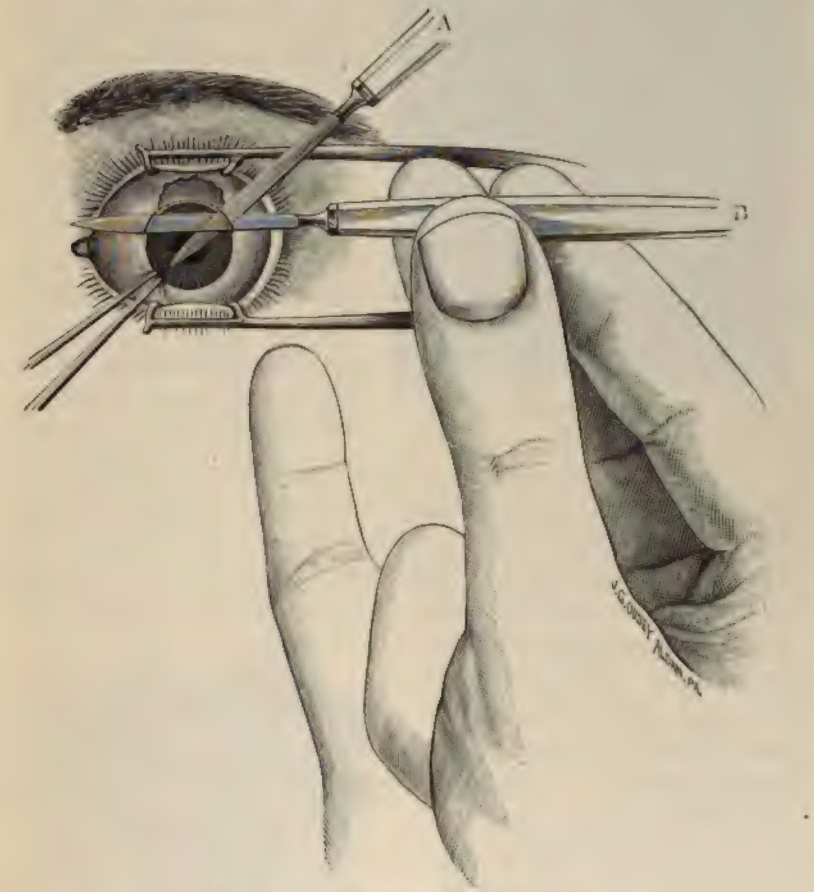


FIG. 149.—THE CORNEAL INCISION.
A, First position; B, Second position (counter-puncture).

The Incision.—By means of a Graefe knife a puncture is made 1 mm. beyond the cornea, and 2 or 3 mm. below a line drawn across the eye at the upper corneal margin; the incision in this operation is not quite equal to one half the circumference of the cornea. The counter-puncture is made at a point on the

opposite side of the cornea which exactly corresponds with the original puncture. The knife is now worked upward through the cornea by a scimiter sweep, the section terminating close to the iris at the upper corneal margin. At this point a small flap in the conjunctiva is usually made by a second sweep (Snellen). Sometimes a slow to-and-fro motion is employed in making the incision.

FIG. 150.—THE PROPER WAY OF HOLDING THE IRIS FORCEPS.

The knife should be slowly withdrawn to prevent any undue escape of the aqueous with consequent prolapse of the iris.

The Iridectomy.— If an iridectomy is to be included in the operation it is made at this stage. The closed iris forceps are introduced and passed into the anterior chamber. The blades of the forceps are now opened and a portion of the iris grasped and slowly drawn through the center of the wound and toward the operator's face. The iris between the cornea and the forceps is now severed by scissors (De Wecker) with one cut. This gives the keyhole iridectomy so much desired.

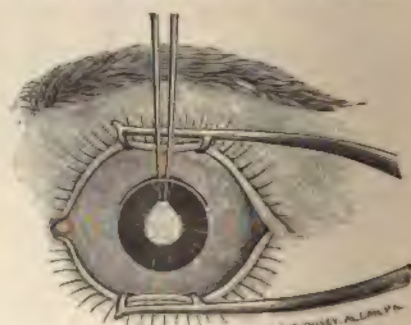


FIG. 151.—GRASPING THE IRIS AT ITS PUPILLARY MARGIN.

Whether an iridectomy should be performed or not is a question that has not yet been finally decided. The advantages of this procedure lie in the fact that the iris is not so likely to be injured during the delivery of the lens, and there is also less danger of its becoming incarcerated in the lips of the wound. On the other hand, an iridectomy will leave a disfigurement and possibly

occasion the patient some slight visual trouble. Some operators, indeed, insist that an iridectomy should be performed some time in advance of the operation for removal of the cataract. The author does not think this procedure is justifiable, and he generally performs an iridectomy during the cataract operation.

Fig. 152.—The Proper Way of Holding the De Wecker Scissors.

The Capsulotomy.—Each cataract is surrounded by a pathologic capsule. This change may be invisible to the naked eye, or very much thickened and dense and easily detected by oblique illumination, and yet it is very difficult to recognize the different types. Diaphanoscopy does not help us; oblique illumination may in some cases, but it is not to be relied on. The author has found that the age of the cataract and the senility of the individual are the best guides. A cataract of one year's growth has a capsule with a bluish cast; a cataract of two years' growth has a capsule with a pale color, moderately dense in appearance, a cataract of three years' growth and over has a capsule of yellow cast, and is dense and inelastic. As the cataract matures the capsule thickens, while the zonule of Zinn, or suspensory ligament, grows thinner or degenerates. This classification of cataracts has been found on the whole fairly accurate. In rupturing the capsule of the lens, a modified Jaeger's cystotome is employed, it being less dangerous than the ordinary straight cystotome in common use

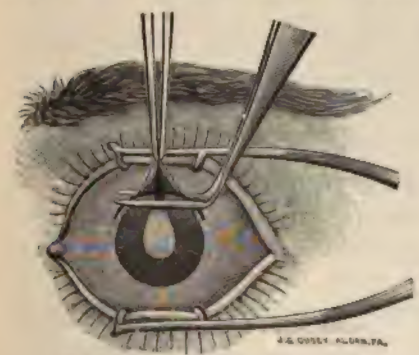


Fig. 153.—The Iridectomy.

(see Fig. 156[12]). The author follows the method adopted by Jaeger, making a rectangular opening in the anterior capsule. The instrument is passed into the anterior chamber, gently pressed against the cornea on the nasal side until it reaches the pupillary margin of the iris below, slightly turned backward and hooked into the capsule—not too deeply—then drawn upward toward the top, lacerating the capsule in its upward movement. It is again passed downward through this same opening, passing across horizontally until the iris boundary is again reached; a second vertical tear is made to the top across to the first incision. In this way a rectangular opening of a large size is made in the anterior capsule. Pressure on the cystotome must of course be avoided, otherwise the lens may be dislocated.

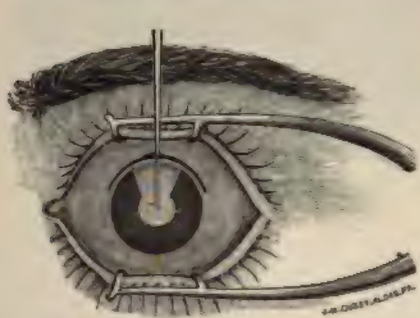


FIG. 154.—THE CAPSULOTOMY.

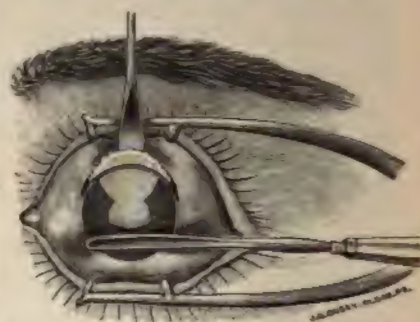


FIG. 155.—THE DELIVERY OF THE LENS.

The Delivery of the Lens.—The patient now directs his eye downward, and pressure is exerted toward the center of the pupil with a Daviel spoon on the lower part of the cornea. This causes the wound to gape, and slowly forces the lens out. A spatula may be applied over the upper edge of the wound and the lens delivered. Great care must be taken to see that all cortical matter is removed from the anterior chamber and that the iris does not become incarcerated in the lips of the wound.

The Toilet of the Wound.—A spatula is now introduced and the pillars of the iris are carefully replaced. If no iridectomy has been performed, and the iris cannot be properly replaced, a small portion must be excised.

The operation is not complete until all particles of cortical matter have been expressed by gentle manipulation and pressure

by the finger through the lower lid or by the spatula, and when this has been accomplished the pupil will be velvet-black.

The eye is now thoroughly cleansed with sterile boric-acid solution and the pupil is contracted by one drop of eserin. In the

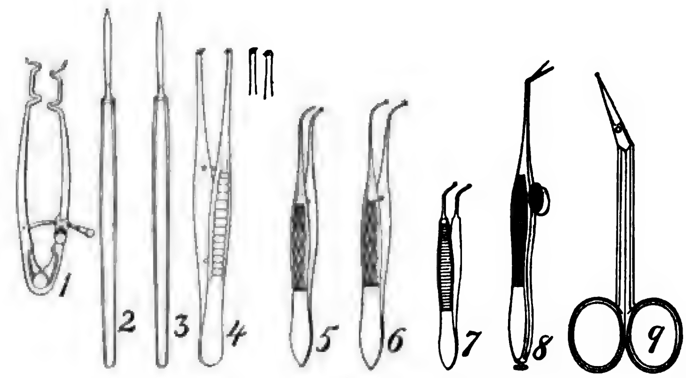
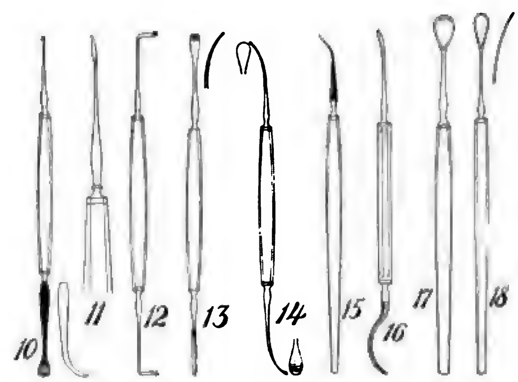


FIG. 156.—INSTRUMENTS USED FOR THE EXTRACTION OF CATARACT.

1. Clark's speculum. 2. Critchett's knife. 3. Von Graefe's knife. 4. Francis' fixing forceps. 5. Waldau's iris forceps. 6. De Wecker's capsular forceps. 7. Windler's iris forceps. 8. De Wecker's iris scissors. 9. Maunoir's angular iris scissors. 10. Von Graefe's cystitome. 11. Langenbeck's cystitome. 12. Author's cystitome. 13. Daviel spoon and spatula. 14. Critchett's cataract spoon. 15 and 16. Tortoise-shell spatulæ. 17. Lens scoop. 18. Vectis.



combined operation the instillation of eserin should not be made. The after-dressing in cataract operations is a very important factor in its successful termination. Every ophthalmic surgeon has his own peculiar way of applying a dressing to an eyeball. The method adopted by the author consists in dropping a few drops of 1-5,000 mercuric iodid solution into the eye immediately after

the operation. The eyelids are then closed and 1 or 2 drams of sterilized vaselin applied. Eye pads and a perforated metal shield, held in place by adhesive plaster, serve to protect the eye. The fact that the author has employed this method of dressing for twenty years, combined with the large number of cases discharged from the hospital in nine or ten days after the operation, speaks well for its efficiency.

Besides minor modifications of the corneal incision operation, such as making the incision downward, we have Pagenstecker's operation, in which the lens is removed in its unbroken capsule. In this operation, which perhaps ranks next in importance to simple extraction, a large flap incision is made in the sclera 1 mm. from the cornea, and, after an iridectomy, the lens is removed in its capsule by a scoop or pressed out by slow manipulation with a Graefe tortoise-shell spatula.

MODIFICATIONS OF THE OPERATION OF EXTRACTION

Surgical operations for the cure of cataract have been performed since time immemorial, but the operation of extraction, as performed at the present time, is of comparatively modern invention. Since Daviel, in 1745, described his method, the operation has undergone numerous modifications, the principal of which are as follows:

1. **Daviel** inserted his knife 0.5 mm. from the edge of the sclera at the horizontal diameter of the cornea, making a flap of the entire lower half of the latter structure. He ruptured the anterior capsule of the lens, but did not perform an iridectomy.

2. **Jaeger,** the elder, performed practically the same operation, but made the flap of the upper half of the cornea.

3. **Jacobson** entered his knife through the cornea 1 mm. below its horizontal diameter, also making the inferior flap at the corneal limbus. An iridectomy was performed in addition.

4. **Steiffein's,** or the Moorfields Hospital (1878–'79) incision, was begun at the upper third of the cornea at the limbus. An iridectomy was also performed to aid in the extraction of the lens through the corneal incision.

5. **De Wecker's** operation differs from the foregoing in that the sclerotic tunic was involved to a slight extent. The knife is

entered through the sclerotic 1 mm. from the corneal limbus, passes through the anterior chamber on a horizontal line 2 mm. from the upper edge of the cornea, and emerges through the sclera on the other side 1 mm. from the corneal margin. The knife is brought upward with a to-and-fro movement until the blade emerges from the upper corneal margin. Iridectomy was not originally a part of this operation, but has since become incorporated with it.

6. **Lebrun** introduced a Graefe knife into the cornea at the limbus, about 1 or 2 mm. below its transverse diameter, and

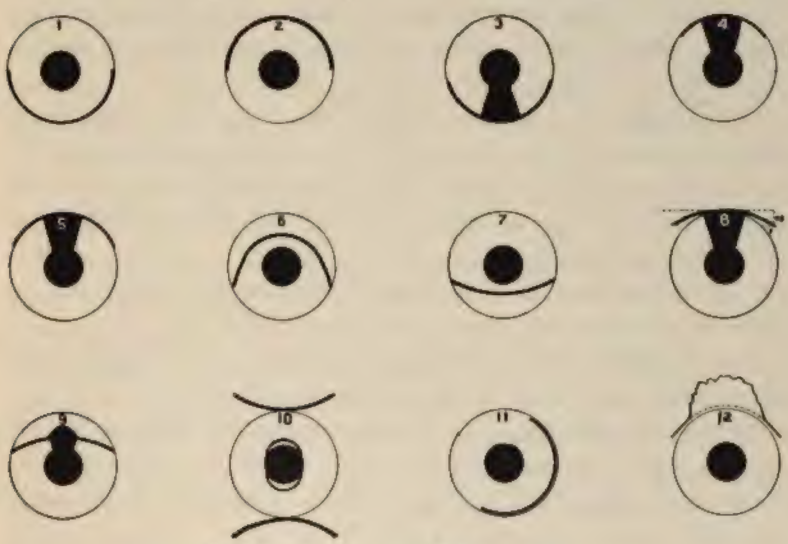


FIG. 157.—CATARACT OPERATIONS.

1. Daviel. 2. Jaeger. 3. Jacobson. 4. Steiffein. 5. De Wecker. 6. Lebrun. 7. Liebreich. 8. Von Graefe. 9. E. Jaeger. 10. Weber. 11. Wenzel. 12. Snellen.

caused it to emerge at a similar point on the other side of the cornea. The cutting edge of the knife was turned upward, so that the plane of the blade formed an angle of 30 degrees with that of the iris. The knife was then drawn upward, still maintaining the angle with the iris, so that its exit was made in about the middle of the upper half of the cornea.

7. **Liebreich** returned to the original operation in part by extracting the lens through an incision in the lower portion of the cornea. His puncture and counter-puncture were made in the

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simplified, and the results improved. The essential requirement of the assistant—to properly keep the eyelids out of the way—is admirably fulfilled by the Ziegler ophthalmostat, an instrument which not only keeps the lids apart, but lifts them away from the eyeball in the proper direction. In all other respects the author performs the operation as laid down by Major Smith.

The preceding operations are mentioned only to show a few of the various stages through which the operation of cataract has passed until it reached the present state of perfection. Among the extraordinary operations for cataract may be mentioned Bourgeois' *external lateral section*, made with a special double knife, the *subconjunctival extraction* by Vacher, Pansier, and Czermak, and the Kalt *method* of closing the incision with a suture. The author has not found enough of encouragement to resort to any of these methods up to the present. The operations described under "Extraction through a Corneal Incision" should be given the preference over those just enumerated.

COMPLICATIONS ENCOUNTERED IN CATARACT EXTRACTION

The incision made in all cataract operations should fulfill certain conditions: (1) to allow the crystalline lens to pass through the opening without the least possible traumatism; (2) to avoid a possible loss of vitreous; (3) to prevent the iris or the iris pillars becoming incarcerated in the lips of the wound; (4) to have the lips of the wound reunite by first intention.

Too Small Incision.—Sometimes the corneal incision is too small to permit the easy exit of the lens. This may be due to poor judgment on the part of the operator or the presence of an abnormally large crystalline lens. In such cases the wound should be enlarged by a specially devised keratome, a blunt-pointed knife, or iris scissors. Any attempt to forcibly press a large lens through too small an opening is attended by contusion of the wound margins, and may be followed by suppuration. Such pressure may give rise to rupture of the zonula with subsequent loss of vitreous.

Hemorrhage may occur from the iris or conjunctiva and often fills the anterior chamber. This can be expressed by gentle manipulation of the spatula upon the cornea, and further outflow of

blood can be controlled by the instillation of adrenalin. The iris forceps may be used to remove any clots that may adhere to the wound margin.

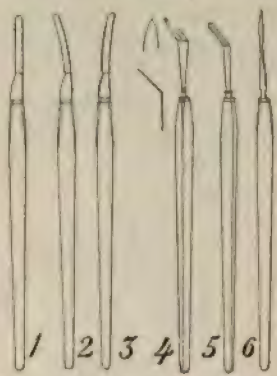

FIG. 158.—INSTRUMENTS FOR ENLARGING WOUND IN CATARACT OPERATIONS.

1. Desmarres' knife. 2. Same; concave edge. 3. Same; convex edge. 4. Priestley Smith's knife. 5. Taylor's knife. 6. Sichel's knife.

Loss of vitreous may be due to its fluid condition or to the incision being made too near the periphery, thus depriving the zonula of its natural support. Excessive intra-ocular pressure brings about the prolapse of the vitreous. This may be caused by the pressure of the speculum or other instruments or by the patient straining. The occurrence of this complication before the lens has been extracted causes the latter to fall back into the vitreous, necessitating the employment of a Taylor's or Critchett's spoon. Loss of vitreous after the lens has been removed is not a serious complication, but it is always a danger signal. Vitreous opacities and retinal detachment may follow it.

Retained Débris.—When small portions of the lens matter remain in the anterior chamber or find lodgment behind the iris, especially in those cases where the lens was immature or the incision rather small and the soft flocculent cortex cannot be stroked out with a Graefe spoon or by pressing the lower lid against the cornea with a gentle upward movement and in this way expressing the lens *débris*, it may become necessary to wash the anterior chamber with McKeown's irrigator or Terson's pipette. The author uses the McKeown nozzles to an eye douche. The force of the saline solution (normal saline) should be very gentle and should be under control of the surgeon himself. The tip of the nozzle should be inserted to the side of the wound and gently pushed into the anterior chamber, the fluid then allowed to flow. The backward current will bring with it much of the cortex. A little dexterity in the manipulation of and precision in handling this instrument soon makes one an expert.

A portion of the lens capsule may be left in the wound, and should be removed to prevent its becoming incarcerated in the

wound during the healing stage. Its removal may be greatly facilitated by the introduction of a bent iris forceps, closed, into the wound, after which they are alternately opened and closed, withdrawing any shreds with which they come in contact.

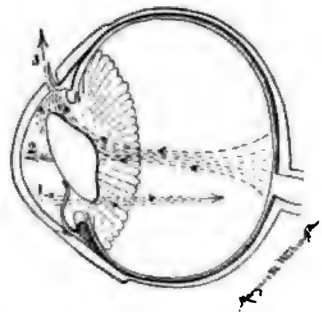

FIG. 159. — DEMONSTRATING THE FORCES WHICH EXPEL THE CRYSTALLINE LENS.

1. Primal pressure with spatula on cornea. 2. Currents returning, tilting lens. 3. Exit of crystalline lens through corneal incision.

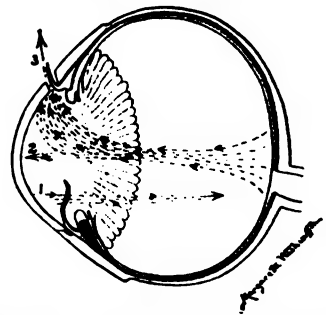

FIG. 160.—CURRENTS OF THE EYE, THE RESULTS OF PRESSURE.

1. Showing primal pressure toward the optic nerve. 2. Currents returning, due to counter pressure. 3. Exit through corneal incision and floating iris.

Prolapse of Iris.—The margins of the iris pillars may become prolapsed into the corneal incision during the expression of the lens, and if allowed to remain so there will be bulging and upward retraction of the pupil. To avoid this, the spatula should be introduced into the corneal wound in every case to make certain that its margins are free, and the iris should be stroked downward. The currents of the fluids of the eye which flow from the wound are strongest at its apex and sweep the iris into this space like a floating flag (see Fig. 160), while the wound heals from its base toward the center. So long as there is the most minute opening, the currents of the eye flow rapidly or slowly according to the intra-ocular pressure, thus keeping the iris constantly in the gaping wound until closure takes place. In many examinations of the iris I have found that its pupillary margin projects forward, and when this iris is bruised or stretched to the point of paralysis, it can be easily understood how the currents of the eye can sweep this floating tissue into the fissure of the incision (Fig. 161). With this explanation it is readily understood why so few simple operations have the beautiful round pupil and the iris in its proper place.

Pain may be experienced during the first twenty-four hours, but is readily relieved by the hypodermatic injection of morphin. Opium, gr. j (0.06), combined with calomel, gr. ij (0.12), or trional in 15 grain (1.0) doses, may be given at night for insomnia.

The anterior chamber may not reform until a week has elapsed from the time of operation. The lips of the wound should be gently touched with a solution of silver nitrate (gr. v (0.3) to ℥j (30.0)) once daily until the wound has united. This is unusual, and should this condition persist for a longer period the corneal wound should be searched for shreds of the capsule, as these are usually the cause. The condition is not serious unless the iris has become incarcerated in the would. Removal of all interfering particles is indicated, as they prevent recovery.

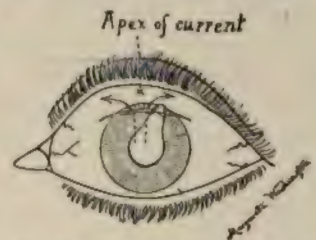

FIG. 161.—INCARCERATION OF THE IRIS DUE TO PARALYSIS OF THE CIRCULAR FIBERS IN SIMPLE OPERATION.

Secondary inflammation of an eye to an improper or uncontrollable degree seldom occurs to-day where the operation has been properly chosen and as well performed. Our present knowledge of pathogenic processes enables us to combat the invasion of such microörganisms as lead on to suppuration and subsequent loss of vision. Yet in spite of all precaution we encounter occasional infection.

Suppuration of the wound may follow uncleanliness as regards instruments and solutions used, but is more often due to the presence of undetected lacrymal disease. It begins during the first forty-eight hours, and is attended by continuous pain and purulent discharge. This is a very serious complication, and may result in destruction of the eye. It receives the same treatment as other suppurative ocular inflammations. Cauterization of the corneal wound and the opening of the incision, thereby affording an exit for the aqueous, have been highly recommended in this condition. Irrigation of the anterior chamber with bichlorid-of-mercury solution (1–10,000), with intra-ocular or subconjunctival injections of a 1–5,000 cyanid-of-mercury solution, have also been em-

ployed. The prognosis in this complication is extremely serious, the condition seeming to defy all treatment.

Striped keratitis may occur after cataract extraction. It is attributed to injury of the cornea by instruments, or the introduction of mercuric solutions into the anterior chamber. It usually passes off in the course of a few days, but may remain as an opacity and greatly obstruct vision.

Iritis nearly always accompanies suppuration of the corneal wound, but may arise independently of that affection from irritation by some of the lens matter or from infection. It does not make its appearance until about the fourth day after the operation, and is ushered in by considerable pain. The inflammation is plastic in character, and may extend to the ciliary body and induce sympathetic ophthalmia in rare cases. The exudate into the pupil is often considerable, and obstructs vision to a great degree. The treatment is that of iritis under other circumstances.

Cystoid Cicatrix.—The cicatrix at the corneal wound occasionally undergoes a cystic change and appears at the end of several weeks as a transparent vesicle (*cystoid cicatrix*). It is induced by incarceration of a portion of the iris, lens capsule, or cortical matter in the corneal wound during the process of healing. It may be necessary to remove this vesicle, which is best done by incising it and touching the spot with a nitrate-of-silver stick. As its results may be mentioned irregular astigmatism, displacement of the pupil, iritis, iridocyclitis, and iridochoroiditis.

Glaucoma may follow cataract extraction, and is usually preceded by iritis with a plastic exudate. It may also follow discission.

Retinal hemorrhages occur in some cases and make their appearance upon the third day after operation. They are most frequent in those of hemorrhagic diathesis.

Delayed healing of the margins of the wound after the extraction of senile cataract in persons of seventy-five years of age and upward is also encountered. The application of silver nitrate ([illegible]-per-cent solution or the solid stick) should be made to the edges of the entire wound. There is no violent reaction, as would be expected.

It must not be forgotten that dexterity in operation, and precision in the performance of it, will enable one to prevent and

also overcome many complications which may arise from want of this skill. The young man of to-day who aspires to the dignity of a skilled operator should be taught by a master first how to *hold* instruments and, second, how to *manipulate* them. "Surgery is the art of assisting Nature, and we should endeavor to follow in her footsteps with gentleness, not to lead them by violence" (Guthrie).

After-treatment.—Both eyelids should be closed and covered with a generous amount (ʒij (8.0)) of sterilized petrolatum, after which the small gauze pads and the large pad are applied and held in place by adhesive straps. A perforated aluminum guard or shield is then fastened over the eye operated upon. All pieces of cotton and threads of gauze should be removed from the ears and face of the patient, as they are irritating and often cause the patient to unconsciously interfere with the dressing. Rest in bed in a darkened room for three or four days is always advisable. The diet during the first twenty-four hours should consist of milk, or hospital soft diet, and if possible a nurse should be in constant attendance during that period. The dressings should be removed at the end of twenty-four hours; the operated eye gently bathed with warm sterile water until all secretions, especially those in the inner canthus, are removed. The water is then changed and the fellow eye is likewise bathed. The operated eye is then gently douched with a warm lotion, such as the following:

℞ Acidi borici	gr. xx;	1.20
Sodii chloridi	gr. xv;	1.00
Aquæ camphoræ, Aquæ destillatæ,	āā fl ℥ij;	60.00

Misce.

The nozzle of the hydrostatic eye douche is placed directly opposite the inner or outer canthus and the fluid allowed to flow between the slightly opened eyelids. Both eyes are similarly douched. A drop of atropin, gr. j (0.06) to ʒij (8.0), solution is dropped into the conjunctival sac of the operated eye only. Both eyes are again closed with sterilized vaselin, and eye pads are held in place by a shield and adhesive strips. If every-

..vorable a more upright position in bed may b...
..oft diet allowed. At the end of three days the ...
.. may be left without bandaging, and at the end
..andage is taken off the eye operated upon one
..th day two to four hours, on the ninth day and ..
..eye is left open all day, being guarded by the ba...
..ht. After this period dark glasses should be ...
..eye is first exposed in many cases the light seem...
..nt, and the term *erythropsia* is applied to this ...
... or blue vision may also be encountered.

..ual acuity should be examined at the terminati...
..om the operation, and again at intervals of two ...
..gmatism and its axis have become stationary; ...
..curred the glasses are ordered for distance, w...
..nvex lens for near work to take the place of ...
... If the vision is not improved by the use of ...
..ult usually lies in the presence of an after-cata...
..rea. Needling or capsulotomy will be requi...
..ot advisable until about three weeks to three ...
..action operation.

..ULES GOVERNING CATARACT OPERATIONS

.. alone is the seat of cataract and vision is ...
..e, operative interference to a large extent in ...
..ount of the difficulty in obtaining perfect ...
.., then again it is indicated for the reason ...
..field obtained compensates for the tempo...
..uced by the binocular diplopia. In young ...
..ay be desired on account of the marked d...
..ctures by its white glistening appearance...
..n is lost in one eye as the result of other ...
.. beginning in the other, extraction shou...
..should be deferred until the conditions m...
..formance—i. e., maturity—are present.

..ticular cataract with loss of useful v...
..be performed upon the eye in which th...
... Operations should not be performed ...
..me sitting. At least six months should in ...

Its specific gravity is about 1.009. Its function is to maintain the shape of the eyeball, support the ocular tunics, and afford a transparent medium of the dioptric system. It may be readily seen that independent disease of the vitreous is not likely to occur, and that most of its affections are secondary to those of the uveal tract, from which it is nourished.

INFLAMMATION OF THE VITREOUS

(*Hyalitis*)

Definition.—Hyalitis is an inflammatory condition of the entire vitreous humor. It seldom if ever occurs as a primary affection, and is attended by the formation of pus in most cases.

Etiology.—Arising as a secondary affection, its causes are those of the primary disease. A low state of the general health is an important factor in its production by lessening the resistance of the vitreous to microbic infection. In most cases the introduction of pus-producing microörganisms is the principal cause, particularly in those instances in which the inflammation follows penetrating wounds, foreign bodies in the eyeball, and choroiditis after the infectious fevers, such as scarlet fever, erysipelas, etc. The inflammation is often preceded by retinitis and uveitis. Spontaneous hyalitis has been said to occur, but this remains very much in doubt.

Varieties.—Suppurative and nonsuppurative.

Suppurative or purulent hyalitis most frequently arises from the proliferation of pathogenic bacteria introduced into the vitreous through penetrating wounds of the eyeball or by means of the blood stream. This accounts for the inflammation that follows foreign bodies in the eyeball, and injuries, and for those apparently obscure cases that occur in the course of scarlet fever, typhoid fever, cerebrospinal meningitis, erysipelas, etc. Suppurative hyalitis may be caused by the entrance of organisms through an apparently healed operation scar. This may occur months or years afterwards, and is promoted by prolapsed iris tissue, a thin scar, or a fistula. The manner in which this affection is brought about is not always clear, and it must be remembered that in most instances the choroid and the hyaloid membrane are first attacked.

Symptoms.—In all cases there is inflammatory reaction of the whole eyeball proportionate to the injury and the involvement of its various structures. An opacity naturally results from the pus that has accumulated in the vitreous humor. This opaque appearance may either be circumscribed or diffuse, the latter condition being the more frequent. When the cornea remains unaffected or transparent, it may be observed that the vitreous presents a yellowish reflex shining through the pupillary space. The pupil may be dilated, due to a retraction of the iris, and posterior synechiæ are formed, due to inflammation of the iris. In the more advanced stages of suppurative hyalitis it may be impossible to examine the fundus on account of the large amount of pus. The change in the consistence of the vitreous causes a diminution in the tension of the eyeball.

The presence of iritis and iridocyclitis may be detected by the synechiæ found, the irregular movement of the pupil, and the deep pericorneal injection.

In those cases in which the pus is markedly circumscribed an error in diagnosis is likely to occur if a careful examination is not made. In such cases the yellowish reflex from the pupil suggests glioma in children, and for this reason circumscribed collections of pus in the vitreous are termed pseudoglioma. They occur most often at the periphery of the chamber near the ciliary region. The tension is always decreased and the symptoms of iritis or iridocyclitis are very prominent, and these, together with the history, should serve to differentiate the two conditions.

The diffuse form of hyalitis has a tendency to become chronic, when the prognosis is especially unfavorable. Shrinking of the exudate follows in those cases in which the eye is not immediately destroyed, resulting in detachment of the coats, rendering the eye a useless organ. Cases of hyalitis, the result of traumatism, have been reported to have made complete and uneventful recoveries. Such cases are, however, very rare.

Treatment.—This varies with the character of the inflammation and its primary cause. If the disease is part of a panophthalmitis, following a penetrating wound, enucleation is necessary at once; but if the disease is not so marked and arises from some general infection, mercurial treatment may be of great benefit. However, even in these cases, the shrinking of the purulent exu-

date after the subsidence of the inflammation will necessitate enucleation at a later period. The discovery of the disease in its early stage is always difficult, but when it is suspected, the free administration of tonic remedies, particularly mercury, may aid in retarding its progress.

The **nonsuppurative form of hyalitis** is subacute or chronic in character, and is always secondary to chronic inflammation of the retina or choroid. The vision is reduced by reason of the retinal or choroidal disease and the pathological opacities in the vitreous. These opacities should not be confounded with the *muscæ volitantes*, which are to a great extent normally present. The opacities of the vitreous in hyalitis are due to disintegration of that structure, and their free movement is rendered possible by the change in the consistence of the vitreous. Their presence can be readily detected by means of the ophthalmoscope. The appearance they present varies from a dustlike mist to thin membranous bands. The method of locating these opacities has been discussed in describing the ophthalmoscope.

Etiology.—The most important conditions which may give rise to this form of hyalitis are ametropia, myopic in character, disease of the neighboring structures, hemorrhage into the vitreous, and constitutional diseases, such as syphilis, gout, rheumatism, anemia, exhausting fevers, etc. Occasionally the affection arises without any apparent cause. This is most frequent in elderly individuals.

Symptoms.—Disturbance of vision is always present, the degree varying with the extent of the disease and the character and location of the opacities. The spots are frequently seen by the patient and occasion considerable annoyance.

Treatment.—In all cases the refraction should be examined and the correcting lenses should be ordered. This alone frequently causes a cessation of the annoyance which the floating specks occasion. The cause should be ascertained and the treatment directed toward it. The use of the eyes for near work should be interdicted.

The mixed form of treatment in syphilitic cases and the free use of tonics and stimulants are commendable at all times. The application of leeches to the temple may be of value if there is acute inflammation. The use of electricity in the form of con-

stant current has rendered invaluable results. The subconjunctival injection of saline solution (sodii saccharat. gr. v–℥j, combined with dionin. gr. xv (1.0)) in the hands of the author has proved successful. 10 to 20 c.c. of the solution being injected in very severe cases, every second day, combined with electric-light baths. The pain is considerable, but may be controlled by the use of an antiphlogistic application. The use of intra-ocular injections of chlorin water has failed to give the results at first attributed to it. Attention to the personal hygiene of the patient should always be insisted upon, as much aid can be derived from a small amount of care in this respect. Tapping of the vitreous through the sclerotic coat has been found of some value by the author.

Prognosis.—Relapses are likely to occur in this variety, although response to appropriate treatment may be prompt at first. In the hemorrhagic opacities absorption seldom occurs without damage to the eye.

OPACITIES IN THE VITREOUS

The formation of opacities in the vitreous may be a physiological or pathological process. Among the physiological opacities may be mentioned the various forms of *muscæ volitantes*. The pathological opacities include foreign bodies, blood, cholesterin and tyrosin crystals, parasites, inflammatory exudate, and neoplasms penetrating the vitreous.

Muscæ volitantes are opaque specks of various size and shape which float before the sight, particularly where the eye is directed toward a bright light. They may also be seen when the eyes are closed. They may or may not be due to organic disease. In some instances they are due to a hypersensitiveness of the perception apparatus by which the normal opacities of the vitreous are noticed. Vision is not particularly interfered with by their presence, but considerable annoyance is occasioned by their movements. Their derivation is in doubt, but it is probable that they have their origin in the amebælike cells at the periphery of the vitreous. They cannot be detected by the ophthalmoscope.

The **pathological opacities** may be derived from without or originate within the vitreous body itself. Nearly all these opaci-

ties are introduced from without with the exception of those due to disintegration of the vitreous, as in the case of cholesterin, tyrosin, and other crystals. The shape of these opacities admits of wide variation, some being minute dots or arranged in dustlike aggregation, while others are elongated or threadlike. Those following hemorrhage are more or less membranous, while those due to parasites or tumors encroaching upon the vitreous are very large in size and usually yellowish-white in color.

Symptoms.—The symptoms are subjective and objective. Subjective symptoms include all the disturbances of vision occasioned by the opacities. The objective symptoms are those brought out by ophthalmoscopic examination and consist of the numerous reflexes or shadows caused by the opacities. Their size, shape, and location may also be determined in this examination.

The mobility of the opacities should always be determined, as it is proportionate to the fluidity of the vitreous. Those which are fixed are usually attached to the retina, choroid, or ciliary processes. If the movement present is very slow the condition of the vitreous is normal, but as the movement increases in rate the consistence becomes altered to a corresponding degree.

Treatment.—The treatment should be directed to the cause of the opacities or the disease with which they are associated. If no assignable cause can be discovered, careful attention should be given the patient's general health. Alteratives, especially mercury in the form of gray powder, potassium iodid, etc., in small but long-continued doses may be of great value. Diuretics and diaphoretics may also be beneficial. Hot baths, 105° to 120° F., followed by hot packs every second day, may be of service.

Electric-Light Bath.—The author has found the electric-light bath an excellent procedure. The method of giving electric sweat baths, as performed at the Medico-Chirurgical Hospital of Philadelphia, is as follows: Articles needed—3 large rubber sheets, 4 blankets, 2 electric bulbs (16-candle power), 1 hot-water bottle, and 1 bed cradle. Protect bed from head to foot with one rubber sheet, place blanket between patient and rubber sheet, then cover with the second blanket, tucking it in well close to the patient, so as to exclude all air. A thermometer is placed on the blanket over the patient. Perspira-

[illegible] begins at a temperature of 110°. The duration [illegible] varies according to the exigencies of the case. The [illegible] is placed over the patient's body and covered with two [illegible] arranged so that they meet in the center. The blankets [illegible] with the rubber sheets in the same manner. The elec- [illegible] are fastened to the cradle in the center, care being taken [illegible] too near the patient's body. Having the blan- [illegible] the rubber sheets arranged in this manner gives excel- [illegible] for watching the light, etc. A hot-water bottle [illegible] placed to the feet, and the blankets and rubber sheets [illegible] tucked in securely around the patient. Hot drinks [illegible] freely during the bath. After removal from bath, [illegible] rub should be given and the patient allowed [illegible]. Subconjunctival injections of normal saline [illegible] valuable. Large doses of salicylate of sodium, [illegible] by Gifford in the case of sympathetic ophthalmia, [illegible] great value by the author in vitreous opacities. [illegible] This varies greatly according to the cause. In [illegible] volitantes the outlook is very favorable, as they [illegible] any disease of the eye. Foreign bodies in [illegible] always followed by a violent inflammatory [illegible] the eye to be lost. Inflammatory exu- [illegible] often leave behind connective-tissue [illegible] contraction cause shrinking of the globe. [illegible] corpus vitreum are of no serious import in [illegible] retrograde changes in the vitreous, and [illegible] complicate operations of any kind on the eye. [illegible] growths eventually destroy the usefulness [illegible] varieties the vision is reduced according to [illegible] opacity, but the annoyance to which it gives rise [illegible] to the size of the opacity.

[illegible] into the Vitreous.—Owing to the absence of [illegible] the vitreous, hemorrhage into it is always de- [illegible] vessels of the retina, choroid, or ciliary body. [illegible] or eyeball is the most frequent cause of this [illegible] well-marked cases it is manifested by great dis- [illegible]. Oftentimes the hemorrhage is so large that [illegible] filled and the retinal reflex is absent or obscured. [illegible] hemorrhage into the vitreous is not rare, and arises

from disease of the blood or ocular blood-vessels. The blood diseases, such as scurvy and purpura, may be responsible in certain cases. Chronic inflammation of the vessel walls from gout, rheumatism, nephritis, arteriosclerosis, diabetes, and allied affections is a more frequent cause. Any sudden rise of blood-pressure in individuals so affected may precipitate apoplexy of the vitreous in the same manner as in other structures. *Vicarious menstruation* may take place into the vitreous in very rare instances. The diagnosis is made largely by the obscuration of the retinal reflex in the ophthalmoscopic examination. The vision increases as absorption takes place, which is seldom complete, membranous masses and pigment often remaining. The outlook in every case depends upon the degree to which absorption occurs.

Treatment.—The patient should be placed at absolute rest in bed with the head highly elevated. Such active measures, as cold compresses, should be applied to the eye, depletion by means of leeches, and cardiac sedatives should be instituted. The presence of syphilis, in any form, indicates the use of mercury or the iodids, or both.

During the first stages, or as soon as possible after the hemorrhage has occurred, diaphoretic and diuretic agents should be given, and in small frequently repeated doses. The diuretics usually employed are the preparations of squill alone, or with calomel. The system meanwhile should be drained of the excess of blood serum by the frequent administration of the sulphate of magnesia. The administration of fluid extract of ergot and gallic acid has also proved very beneficial in such cases. Iodid of potassium should be given early in all cases on account of its absorbent properties. Successful ligation of the common carotid artery when the hemorrhage was malignant and recurrent has been reported in a number of instances.

Alterations in the Consistence of the Vitreous.—The consistence of this structure admits of two variations: increase and decrease. Increased consistence probably exists in those conditions in which all the fluids of the body undergo an increase in their solid constituents, but its presence has yet to be demonstrated. A far more frequent condition is decreased consistence. This is also known as synchysis or fluidity of the vitreous. It is accompanied by choroidal disease, and is manifested by dimin-

Symptoms.—In all cases there is inflammatory reaction of the whole eyeball proportionate to the injury and the involvement of its various structures. An opacity naturally results from the pus that has accumulated in the vitreous humor. This opaque appearance may either be circumscribed or diffuse, the latter condition being the more frequent. When the cornea remains unaffected or transparent, it may be observed that the vitreous presents a yellowish reflex shining through the pupillary space. The pupil may be dilated, due to a retraction of the iris, and posterior synechiæ are formed, due to inflammation of the iris. In the more advanced stages of suppurative hyalitis it may be impossible to examine the fundus on account of the large amount of pus. The change in the consistence of the vitreous causes a diminution in the tension of the eyeball.

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Treatment.—This varies with the character of the inflammation and its primary cause. If the disease is part of a panophthalmitis, following a penetrating wound, enucleation is necessary at once; but if the disease is not so marked and arises from some general infection, mercurial treatment may be of great benefit. However, even in these cases, the shrinking of the purulent exu-

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Symptoms.—Disturbance of vision is always present, the degree varying with the extent of the disease and the character and location of the opacities. The spots are frequently seen by the patient and occasion considerable annoyance.

Treatment.—In all cases the refraction should be examined and the correcting lenses should be ordered. This alone frequently causes a cessation of the annoyance which the floating specks occasion. The cause should be ascertained and the treatment directed toward it. The use of the eyes for near work should be interdicted.

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OPACITIES IN THE VITREOUS

The formation of opacities in the vitreous may be a physiological or pathological process. Among the physiological opacities may be mentioned the various forms of *muscæ volitantes*. The pathological opacities include foreign bodies, blood, cholesterin and tyrosin crystals, parasites, inflammatory exudate, and neoplasms penetrating the vitreous.

Muscæ volitantes are opaque specks of various size and shape which float before the sight, particularly where the eye is directed toward a bright light. They may also be seen when the eyes are closed. They may or may not be due to organic disease. In most instances they are due to a hypersensitiveness of the perception apparatus by which the normal opacities of the vitreous are noticed. Vision is not particularly interfered with by their presence, but considerable annoyance is occasioned by their movements. Their derivation is in doubt, but it is probable that they have their origin in the amebælike cells at the periphery of the vitreous. They cannot be detected by the ophthalmoscope.

The **pathological opacities** may be derived from without or originate within the vitreous body itself. Nearly all these opaci-

ties are introduced from without with the exception of those due to disintegration of the vitreous, as in the case of cholesterin, tyrosin, and other crystals. The shape of these opacities admits of wide variation, some being minute dots or arranged in dustlike aggregation, while others are elongated or threadlike. Those following hemorrhage are more or less membranous, while those due to parasites or tumors encroaching upon the vitreous are very large in size and usually yellowish-white in color.

Symptoms.—The symptoms are subjective and objective. Subjective symptoms include all the disturbances of vision occasioned by the opacities. The objective symptoms are those brought out by ophthalmoscopic examination and consist of the numerous reflexes or shadows caused by the opacities. Their size, shape, and location may also be determined in this examination.

The mobility of the opacities should always be determined, as it is proportionate to the fluidity of the vitreous. Those which are fixed are usually attached to the retina, choroid, or ciliary processes. If the movement present is very slow the condition of the vitreous is normal, but as the movement increases in rate the consistence becomes altered to a corresponding degree.

Treatment.—The treatment should be directed to the cause of the opacities or the disease with which they are associated. If no assignable cause can be discovered, careful attention should be given the patient's general health. Alteratives, especially mercury in the form of gray powder, potassium iodid, etc., in small but long-continued doses may be of great value. Diuretics and diaphoretics may also be beneficial. Hot baths, 105° to 120° F., followed by hot packs every second day, may be of service.

Electric-Light Bath.—The author has found the electric-light bath an excellent procedure. The method of giving electric sweat baths, as performed at the Medico-Chirurgical Hospital of Philadelphia, is as follows: Articles needed—3 large rubber sheets, 4 blankets, 2 electric bulbs (16-candle power), 1 hot-water bottle, and 1 bed cradle. Protect bed from head to foot with one rubber sheet, place blanket between patient and rubber sheet, then cover with the second blanket, tucking it in well close to the patient, so as to exclude all air. A thermometer is placed on the blanket over the patient. Perspira-

tion usually begins at a temperature of 110°. The duration of the bath varies according to the exigencies of the case. The bed cradle is placed over the patient's body and covered with two blankets arranged so that they meet in the center. The blankets are covered with the rubber sheets in the same manner. The electric bulbs are fastened to the cradle in the center, care being taken not to have them too near the patient's body. Having the blankets and the rubber sheets arranged in this manner gives excellent opportunity for watching the light, etc. A hot-water bottle should be placed to the feet, and the blankets and rubber sheets should then be tucked in securely around the patient. Hot drinks may be given freely during the bath. After removal from bath, a warm alcohol rub should be given and the patient allowed to rest for an hour. Subconjunctival injections of normal saline solution are most valuable. Large doses of salicylate of sodium, as advocated by Gifford in the case of sympathetic ophthalmia, have been found of great value by the author in vitreous opacities.

Prognosis.—This varies greatly according to the cause. In the case of *muscæ volitantes* the outlook is very favorable, as they are unconnected with any disease of the eye. Foreign bodies in the vitreous are nearly always followed by a violent inflammatory reaction that may cause the eye to be lost. Inflammatory exudates and blood pigment often leave behind connective-tissue bands, which by their contraction cause shrinking of the globe. Fatty crystals in the corpus vitreum are of no serious import in themselves, but suggest retrograde changes in the vitreous, and consequently contraindicate operations of any kind on the eye. Parasites and morbid growths eventually destroy the usefulness of the eyeball. In all varieties the vision is reduced according to the size of the opacity, but the annoyance to which it gives rise is in indirect proportion to the size of the opacity.

Hemorrhages into the Vitreous.—Owing to the absence of blood-vessels in the vitreous, hemorrhage into it is always derived from the vessels of the retina, choroid, or ciliary body. Injury to the head or eyeball is the most frequent cause of this condition, and in well-marked cases it is manifested by great disturbance of vision. Oftentimes the hemorrhage is so large that the chamber is filled and the retinal reflex is absent or obscured. Spontaneous hemorrhage into the vitreous is not rare, and arises

from disease of the blood or ocular blood-vessels. The blood diseases, such as scurvy and purpura, may be responsible in certain cases. Chronic inflammation of the vessel walls from gout, rheumatism, nephritis, arteriosclerosis, diabetes, and allied affections is a more frequent cause. Any sudden rise of blood-pressure in individuals so affected may precipitate apoplexy of the vitreous in the same manner as in other structures. *Vicarious menstruation* may take place into the vitreous in very rare instances. The diagnosis is made largely by the obscuration of the retinal reflex in the ophthalmoscopic examination. The vision increases as absorption takes place, which is seldom complete, membranous masses and pigment often remaining. The outlook in every case depends upon the degree to which absorption occurs.

Treatment.—The patient should be placed at absolute rest in bed with the head highly elevated. Such active measures, as cold compresses, should be applied to the eye, depletion by means of leeches, and cardiac sedatives should be instituted. The presence of syphilis, in any form, indicates the use of mercury or the iodids, or both.

During the first stages, or as soon as possible after the hemorrhage has occurred, diaphoretic and diuretic agents should be given, and in small frequently repeated doses. The diuretics usually employed are the preparations of squill alone, or with calomel. The system meanwhile should be drained of the excess of blood serum by the frequent administration of the sulphate of magnesia. The administration of fluid extract of ergot and gallic acid has also proved very beneficial in such cases. Iodid of potassium should be given early in all cases on account of its absorbent properties. Successful ligation of the common carotid artery when the hemorrhage was malignant and recurrent has been reported in a number of instances.

Alterations in the Consistence of the Vitreous.—The consistence of this structure admits of two variations: increase and decrease. Increased consistence probably exists in those conditions in which all the fluids of the body undergo an increase in their solid constituents, but its presence has yet to be demonstrated. A far more frequent condition is decreased consistence. This is also known as synchysis or fluidity of the vitreous. It is accompanied by choroidal disease, and is manifested by dimin-

ished tension of the eyeball, rapid movement of vitreous opacities, and tremulousness of the iris. The importance of this condition arises from the fact that it occurs in elderly persons in whom cataract is also frequent, and any operation in such cases is likely to be followed by loss of vitreous and collapse of the eyeball. There is no treatment.

Synchysis Scintillans. — This is manifested by fluidity of the vitreous body and by the formation of crystals of leucin, tyrosin, cholesterin, etc. The presence of these crystals is termed *synchysis scintillans.* It often gives rise to lowering of the intra-ocular tension, luxation of the lens, and detachment of the retina. It is a pathological condition, and may be distinguished from *muscæ volitantes* by the glistening reflex seen with the ophthalmoscope. The appearance they present is not unlike that of a shower of silver specks. They are derived from the blood directly or indirectly. This condition is said to occur more frequently in alcoholics, individuals with diseases of the joints, and is occasionally encountered in apparently healthy senile subjects.

Treatment does not appear to have any influence.

Fatty degeneration of the vitreous, also evidenced by white glistening spots, has been described (Iwanoff). It is usually physiological—i. e., an evidence of senile decay.

As a late result of degenerative changes, the vitreous may undergo contraction and shrinking, giving rise to detachment. This renders the eye useless, but interference is unnecessary unless inflammatory symptoms occur, when enucleation is indicated.

ANOMALOUS CONTENTS OF THE VITREOUS

Under this heading may be conveniently described those conditions which are not, strictly speaking, diseases, but are abnormal affections. These include blood-vessels, persistent hyaloid artery, parasites, foreign bodies, and growths.

Blood-vessels in the vitreous are rare, and when present are nearly always localized in front of the head of the optic nerve, sometimes obscuring it. They are of no special pathological significance.

Persistent Hyaloid Artery.—The hyaloid artery usually disappears by absorption during the latter period of fetal life. In

some extremely rare cases, however, remains of this artery in the vitreous have been traced by careful ophthalmoscopic examinations, either in the form of a short, dark stripe, or of a dark thread running through the vitreous from the optic disk toward the posterior pole of the lens. One case was noted in which the artery carried blood, appearing as a red cordlike structure by incident light. Liebreich has reported a case in which there existed a physiological cupping of the optic nerve, together with a persistent hyaloid artery, the latter being distinctly traced up to

FIG. 162.—NEWLY FORMED BLOOD-VESSELS IN THE VITREOUS. (Author's cases.)

its point of origin—the central artery of the retina. One case, a boy sixteen years of age, came under the observation of the author's assistant, Dr. F. K. Brown, at the Medico-Chirurgical Hospital, in which a transparent hyaloid canal existed in the left eye. In this case a small venous twig took its origin in the central vein of the disk, running, with a slight bend, some distance into the vitreous humor of the eye, and then making a loop, returning and twisting itself three times around its base like the tendril of a grapevine, terminated apparently in one of the large central veins.

Parasites in the Vitreous.—Filaria, hydatids, and cysticerci have occasionally been observed in the vitreous. Sight is always impaired, the interference being proportional to the number of parasites infesting this body.

On examination of the cysticercus it is found to present a bluish-white appearance. Following its death the parasite is

found to be so covered with lymph as to be rendered recognizable by the aid of the ophthalmoscope, and if the parasite is not removed, sight may be lost and the eyeball undergo atrophic

FIG. 163.—BLOOD-VESSEL PROJECTING INTO THE VITREOUS. (Author's case; see text.)

changes. The author remembers, while a student in Vienna, a case which came under the observation of Professor Arlt. An effort was made to remove it, which was unsuccessful. Its movement could be readily seen with the ophthalmoscope. The author has never seen a case in this country. They are mostly observed in Germany or Austria. Recently Würdemann, of Seattle, and Love, of Philadelphia, have each reported a case.

Foreign Bodies in the Vitreous.—It is very interesting to note the numerous foreign bodies that may enter this region, and of still greater interest are the various results that are likely to follow after their entrance.

If a foreign body becomes lodged in the vitreous it very frequently causes a most severe and destructive inflammation of the tissues through which it found entrance, or with which it lies in contact. If it has entered through the cornea, this body, as well

as the iris, often becomes violently inflamed; the lens, through which it must have passed, becomes greatly swollen and cataractous, thus tending further to increase the severity of the inflammation. When the foreign body lies in the vitreous and close to the retina a severe inflammation of the retina is frequently produced together with an inflammation of the choroid, which may perhaps lead to atrophy of the globe. In a short time after the foreign body has entered the vitreous the latter becomes clouded, especially in the neighborhood of the foreign body; later the foreign body becomes encysted, and the vitreous becomes diffusely clouded and filamentous opacities float about in it, thus causing a great disturbance of vision.

Although the unfavorable results just mentioned must be considered as possibilities in all foreign-body cases, they are not as frequent as the modern text-books would seem to indicate. In my own experience I have observed a number of cases in which the foreign body after entering the vitreous produced very little reaction, and even in the case of large bodies the results predicted have not always taken place. In one patient a needle of steel passed through the cornea, iris, lens, and vitreous and embedded itself in the posterior portion of the eyeball in the retina, where it could be easily seen by means of the ophthalmoscope. Its track was shown by a delicate line of scar tissue. When the patient came under my charge at the Medico-Chirurgical Hospital several weeks had elapsed since the occurrence of the accident and the eye was comparatively quiet. The foreign body was subsequently located by the X-ray. In another case the patient was shot in the face, the shot entering the eyeball. Hemorrhage followed immediately and vision was reduced to the perception of hand movement at a few inches from the eye. The patient was treated by his family physician, Dr. Glendon, of Cedarville, N. J., for three weeks by the ordinary methods of combating inflammation. The vision improved during this period and continued to improve, so that when I last heard from him it was $\frac{6}{9}$ for distance, and he was able to read the newspaper with comfort. The patient was brought to me for an opinion as to the advisability of enucleation on account of the foreign body in the eye. Upon careful examination of the eye it was found that the shot had penetrated the sclerotic just above the upper line of the external muscle, a short

distance in front of the equator. By extreme convergence another opening could be distinctly seen on the same line, but just behind the equator, showing by the indenture and choroidal staining that the shot had gone in and then out through the sclerotic coat and buried itself deep in the orbit. This was subsequently confirmed by the X-ray. Enucleation was, therefore, not advised.

There are still other cases in which, although the injury may be followed by severe inflammation, the foreign body will become encysted, and the vitreous humor gradually regains its transparency after the subsidence of the inflammatory symptoms. Frequently, after a foreign body has remained encysted and dormant for a number of years, it is liable to give rise to inflammatory symptoms, which may lead to atrophy of the globe, or produce sympathetic ophthalmia.

The resistance of an eye containing a foreign body, or through which one has passed, is always lessened and requires surveillance, as it is likely to become seriously inflamed at some remote period from the most trivial cause.

Treatment.—If the position of the body can be determined, and its removal is even remotely possible, the attempt should at least be made. If the fragment be of metallic nature, removal by the electric magnet may be practicable; if the body quivers on the approach of the magnet the indications are favorable for removal by this means. The needle may be introduced through the original wound, or a new incision made through the sclerotic close to the location of the foreign body. The position of the patient's head must be carefully considered if the foreign body moves with motions of the head, and it is sometimes necessary to perform the operation with the patient seated. Should the foreign body be located in the lens, this structure should be immediately removed, as in cataract operation. If the fragment is located directly behind the lens, its removal may be effected at the same time, or immediately after the removal of the lens. If the foreign body can only be removed by sacrificing the lens, this sacrifice should be made, since a foreign body in the vitreous rarely fails to set up hyalitis or glaucoma; it may also produce retinal detachment or give rise to sympathetic ophthalmia, as already mentioned.

Cold compresses should be applied to the eye and leeches to

the temple, with the view of allaying the attendant intense inflammation. The pupil should also be dilated to its full extent, and the eye placed at rest by the local administration of atropin, and if a suppurative iritis or iridocyclitis supervenes, it may be necessary to administer mercury. These measures are, of course, to be resorted to before the operation is performed. (See chapter on Foreign Bodies.)

Growths such as glioma and sarcoma may occupy the vitreous chamber prior to their rupture through the globe. The vitreous is displaced and vision is reduced as the growth increases. An alteration in the pupillary reflex is suggestive of such conditions. They are fully considered elsewhere in this work.

CHAPTER XVI

GLAUCOMA

GENERAL CONSIDERATIONS

THE term *glaucoma* was first used by Hippocrates and the ancient Greeks, and was applied to all opacities located posteriorly to the pupil. The Greeks of a later era, however, restricted the term to the incurable opacities behind the pupil, while to those amenable to treatment they applied the name *hypochyma*; the former they supposed to be a lesion of the lens, the latter a concretion in front of the lens. Later on the term was used in a more restricted sense, being limited to those eyes which, when viewed through the dilated pupil, presented a green reflex. The cause of this reflex, however, was not understood. The disease was believed to be incurable.

Some of the earlier physicians, Brisseau (1709), claimed that the disease had its seat in the vitreous humor, while others, de St. Yves (1722), held that the real seat of the affection was in the retina and optic nerve. At a still later period it was believed that glaucoma was due to a peculiar inflammation of the choroid, which occurred most frequently in gouty or rheumatic individuals.

The characteristic symptoms of this affection were not generally recognized by physicians until the advent of the ophthalmoscope, which was invented by Helmholtz in 1851.

Mackenzie, in his valuable work on "Diseases of the Eye," [1] gives a very good description of glaucoma, which is not so widely at variance with modern views on the subject. The increased tension of the eye in glaucoma was pointed out by him in 1830. In the treatment of this disease he mentions puncture of the sclerotic with a broad iris knife. He also suggested puncturing the

[1] Page 899, 1854 edition.

cornea and evacuating the aqueous humor, and stated that this procedure resulted in temporary improvement of vision, as well as relief of the pain. Removal of the crystalline lens is also mentioned by him. He says this procedure sometimes improves the vision of the patient. The beneficial results following this operation are, in the light of our present knowledge, evidently due to the fact that the wound made in the eye acts as a filtration channel, and relieves the hypertension, and around this fact the various modern substitutes for iridectomy seem to be revolving.

Many points, however, were still needed to complete the symptomatology and diagnosis of glaucoma, and the brilliant von Graefe was the first to supply these points and advance the modern theory of glaucoma. Not only, however, did he accurately describe the disease, but planned an operation which rendered the cure of this hitherto incurable affection possible.

Von Graefe pointed out the presence of arterial pulsation in the optic nerve in glaucoma, which pulsation, he observed, was either spontaneous, or might be produced by slight or moderate pressure on the eyeball. At the same time he discovered the cause of the peculiar appearance of the optic disk, which, together with other observers, he had previously ascribed to an arching forward of the optic nerve fibers at their entrance, but which in reality is due to a pathologic excavation or cupping of the disk at this point. He at once recognized the important connection between the excavation and arterial pulsation, and the increased tension of the eyeball.

In his endeavor to prevent or permanently lower this increased tension he first employed the usual remedies—mercurials, antiphlogistics, diuretics, and diaphoretics. This treatment proving unsuccessful, myotics were next employed, it being known that these drugs decreased intra-ocular tension. These drugs, however, only gave temporary relief. He next decided upon paracentesis; this operation, also, was followed by only temporary improvement.

Having previously observed that ulceration and infiltrations of the cornea, partial staphyloma of the cornea, and staphyloma of the sclerotic were cured, or at least improved, by an iridectomy, he decided to perform this operation in glaucoma for the purpose of lowering the abnormal tension. He first performed

an iridectomy for glaucoma in June, 1856, and found that not only was the intra-ocular tension permanently diminished, but that, indeed, the operation might be regarded as a true curative measure in this disease. The results obtained are world-renowned, and the most eminent ophthalmologists consider this operation the only cure for glaucoma.

Definition.—Glaucoma may be defined as a disease of the eye, characterized essentially by *abnormally increased intra-ocular tension*, this fundamental sign being more or less associated with the following symptoms, which in turn vary according to the variety and severity of the process: Dilatation, and interference with the shape of the pupil; sluggish or immobile iris; haziness and partial or complete anesthesia of the cornea; shallowness to extinction of the anterior chamber; pericorneal injection, often of a coarse variety; cupping of the optic disk and arterial pulsation on the same; contraction of the visual fields either partially or completely on the nasal side, with a variety of other alterations in form and color. In addition there are various subjective symptoms to be presently described. If untreated, the disease terminates in blindness.

Pathogenesis.—The pathogenesis and pathology of glaucoma are still somewhat obscure. Many different theories have been advanced by leading authorities to explain the cause of the abnormally increased intra-ocular tension in glaucoma. Thus far, however, only two are worthy of serious attention. These may be termed the theory of hypersecretion and that of retention of the intra-ocular fluids.

The hypersecretion of fluids is said to be caused by irritation of the nerves governing the secretory functions. The simplicity of this theory is beautiful, but when, however, we attempt to explain the manner in which the fluids are retained the problem becomes more difficult. The aqueous fluid is a transudation derived from the vessels of the ciliary body, and the rate of its formation depends directly on the arterial blood-pressure. It is a well-known fact that it passes out of the anterior chamber by way of the ligamentum pectinatum iridis and the canal (or venous sinus) of Schlemm, and it finds a ready outlet into the suprachoroidal space; but it must not be forgotten that the iris with its veins and *crypts* also plays an active part as

an accessory absorbing surface. Henderson considers that primary glaucoma is a component of two factors, the first brought about by the physiological sclerosis of the cribriform ligament and the second variable and vascular. All the phenomena of glaucoma follow as consequences of a closure of the pectinate (cribriform) ligament due to sclerosis. One cause for this fibrosis is to be found in the traction on it of the ciliary muscle, especially in hyperopic eyes. As sclerosis is seen in normal eyes with advancing years, he regards the sclerosis in glaucomatous eyes as a pathological excess of a physiological process.

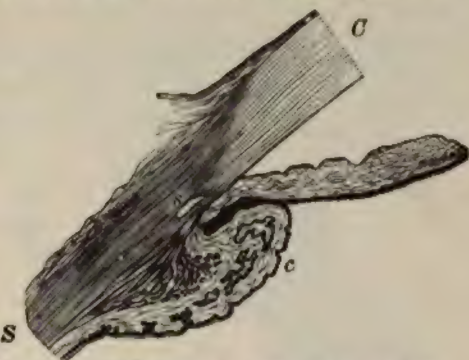


FIG. 164.—IRIS AND CILIARY BODY IN RECENT INFLAMMATORY GLAUCOMA. Magnified 9 × 1.

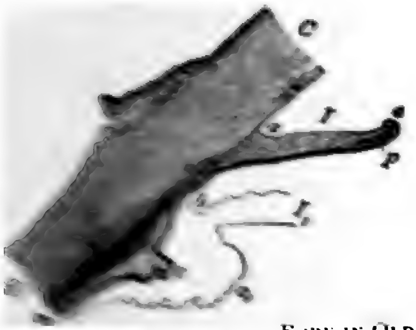
The ciliary process, *c*, is so greatly swollen that it pushes the root of the iris forward and presses it against the sclera, *S*, and the cornea, *C*. The sinus of the anterior chamber, which should lie somewhat behind Schlemm's canal, *s*, is thus closed. The ciliary muscle shows the pronounced development of the circular muscular fibers (Muller's portion), characteristic of the hyperopic eye.

If by sclerosis of the pectinate ligament there follows an obstruction to the outflow of the aqueous in that direction, the work of absorption is more and more thrown upon the iris crypts. If they are unequal to this, the intra-ocular pressure rises, congestion of the iris tissue ensues, and the peripheral margin of the iris is brought in contact with and becomes adherent to the cornea, more or less completely blocking up the angle of the anterior chamber. Henderson considers the adhesion of the iris as being secondary to the blocking of the path into Schlemm's canal, and not as the cause of the obstruction.

Priestley Smith has advanced an ingenious as well as a plausible explanation of the mechanism of retention. He claims that there is a narrowing, or even an obliteration, of the canal of Petit, the space situated between the edge of the lens and the ciliary process; this is caused by an enlargement of the lens, which always takes place in old age. Petit's canal is the route through which the excreted fluids of the vitreous chamber pass forward to the canal of Schlemm. If, therefore, Petit's canal be

[illegible] the increased pressure from behind will push the lens [illegible] and shut off the canal of Schlemm by the iris, as men- [illegible] a point which was left unexplained by previous [illegible]

[illegible] attack of inflammatory glaucoma may be precipitated by [illegible] of the pupil from any cause, or mental and physical conditions which increase the general or local blood-pressure in an eye in which the filtration power, through the pectinate ligament, has been diminished and therefore predisposed to glaucoma. The result of an increased blood-pressure under such circumstances is the production of an increased amount of aqueous which cannot find a ready means of escape, excepting through the iris.



[illegible] Body in Old [illegible] Magnified

[illegible] and the [illegible] The root [illegible] sclera, S, and the cor- [illegible] pressed against them [illegible] of the iris is [illegible] lies in front of [illegible] of the ante- [illegible] Wherever [illegible] has been thinned [illegible] for example [illegible] more than the [illegible] of the iris. [illegible] narrower [illegible] pupillary bor- [illegible] turns forward [illegible] pupillæ, p. [illegible] eversion. The [illegible] become atrophic, [illegible] and in fact more [illegible] so that it is now [illegible] interval. The [illegible] muscle, m, and

The theory of retention, in whatever way it may be explained, has, at the present time, the greater number of supporters, although it is open to criticism. Some cases of inflammatory glaucoma which have come under our notice have manifested [illegible] in the general blood-pressure as to suggest [illegible] secretion being associated with retention. [illegible] systematic study of the blood-pressure should [illegible] cases of glaucoma.

[illegible] theories that have been advanced may be men- [illegible] shrinking of the sclerotic, swelling of the

underlying cause by blocking the channels of exit by the attendant adhesions. Glaucoma as a sequel to adherent leucoma has been described (Fuchs).

Treatment.—Owing to the changes in the various structures of the eye, the operations of iridectomy and sclerotomy are not attended by the uniformly good results as otherwise, and frequently fail to lessen the tension or to prevent further enlargement of the globe. Dislocation of the lens and loss of vitreous are common complications. Less dangerous methods of treatment consist in the instillation of myotics and paracentesis. Incision of the adherent tags of tissue which block the various channels at the angle of the anterior chamber, by passing the point of a knife into its extreme angle, has also been suggested. Enucleation, however, becomes necessary when the deformity is marked, as the eye in these cases is useless as a visual organ.

Glaucoma may further be said to be *primary* or *secondary*.

Primary glaucoma is that variety which arises without any obvious cause, but the influence of certain predisposing factors in its production is well known, and should never be completely ignored.

Age is of great importance in this connection, as the condition is most frequent at the extremes of life. It may be prenatal or date from birth, as was seen in the consideration of congenital glaucoma. During early adult life the affection is seldom observed excepting those cases of congenital origin, and it may be considered as extremely rare under thirty years of age. With the advent of presbyopia primary glaucoma gradually increases in frequency, until at sixty years its occurrence may be looked upon as rather common.

Women are subjects of glaucoma with greater frequency than men, and the liability to the congestive variety of the disease is also greater in females.

Heredity exercises slight influence upon the production of glaucoma, as cases have been recorded in which several members of the same family, extending over two or three generations, had been affected.

Race is said to have some effect in predisposing to the condition, and it has been repeatedly stated that Jews, Egyptians, and negroes are most liable to glaucoma. It can be readily seen that

deductions from observations in this connection depend entirely upon the geographical location of the observer.

Refraction is an important predisposing factor. About one half of all the cases of primary glaucoma occur in individuals the subjects of *hyperopia,* and in it high myopia is extremely infrequent. Prolonged near-work with excessive functional activity of the ciliary muscle in hyperopic persons also predisposes to glaucoma. In these cases an attack is usually precipitated by the instillation of atropin or some similar cycloplegic, so that in persons past forty or forty-five years of age it is a good rule to avoid the instillation of these drugs in order to guard against this complication.

The size of the cornea is of importance, as those corneæ having a horizontal diameter of less than 10 mm. seldom escape glaucoma. Small corneæ belong, as a rule, to small globes, and small eyes are more liable to primary glaucoma than large ones.

Among the remaining predisposing factors may be mentioned grief, loss of sleep, shock from operation upon the other eye, local injuries, such as abrasion and ulcer of the cornea, facial neuralgia, cold, fatigue, constipation, circulatory and pulmonary affections, etc.

Primary glaucoma may still further be divided into inflammatory and noninflammatory glaucoma.

Inflammatory glaucoma, as the term indicates, is attended by congestion or inflammation of the ocular tissues, and includes an *acute* and *chronic* variety.

Chronic noninflammatory glaucoma is characterized by the absence of inflammatory phenomena, and is typified by *glaucoma simplex.*

Acute, Inflammatory, or Congestive Glaucoma (*Prodromal Stage*).—In this form of glaucoma there is held to be a group of premonitory symptoms, but it is hard to understand how these symptoms can appear before an actual increase of tension has taken place. Among these so-called premonitory symptoms are sudden failure of power of accommodation, fogginess of vision, and colored halos around artificial lights (iridescent vision).

The cornea is somewhat cloudy in its central portion, and the anterior chamber is shallow in this prodromal stage. In addition may also be mentioned the sluggish dilated pupil, the slight in-

crease in the intra-ocular tension, and the circumcorneal injection. The patient complains of headache and ocular pain, yet by far the most common prodrome is the rapid failure of accommodation, so that a marked increase in presbyopia should always excite suspicion.

The duration of these phenomena may vary from a few hours to several days, usually subsiding only to recur with renewed vigor at a later period. At first the attacks are few in number, but later they become more numerous, although they may not be sufficiently severe to attract the patient's attention. The severity of the attacks increases with their frequency, and each attack usually leaves the eye in a worse condition. Such a premonitory stage may exist for a year, or even longer, but cases also occur in which there is no premonitory stage. (See Glaucoma fulminans.)

The Attack.—The onset of a true glaucomatous attack usually takes place at night, and is characterized by violent radiating pain, excessive lacrymation, and pericorneal injection; the cornea is steamy and anesthetic,[1] and the iris in consequence is discolored; the anterior chamber of the eye is shallow while the pupil is moderately dilated, and the reflex is of a greenish hue. The patient often complains of subjective sensations of light, called "light flashes," and vision is partly or completely lost. When the intra-ocular pressure rises it may be accompanied by vomiting and other functional disturbances which simulate bilious attacks and tend to deceive both patient and physician. Headache and ciliary neuralgia are also present in the early attacks. In some cases such an attack as has just been described may pass away in the course of two or three days, although it should be understood that there is not a complete remission of the symptoms. Some visual defect always remains, the pupil is sluggish, and the tension is still above the normal.

In the course of a few weeks or months there is a second similar attack, and this, too, may gradually pass away, although the eye is left in a worse condition than after the complete subsidence

[1] The sensibility of the cornea is determined by gently touching the structure with a finely rolled wisp of cotton. If sensation is present it will be recognized by the patient, and the reflex closure of the lids will occur. None of the fibers of the cotton should touch the conjunctiva.

of the first attack. The succeeding attacks occur at shorter intervals, and if the eye is examined during a remission the vitreous and cornea are found to be clouded to a very considerable degree, the optic papilla cupped, and an arterial pulsation may readily be observed. Donders many years ago observed that the arterial pulse seen in the fundi of glaucomatous eyes is often transitory, at times going hand in hand with the transient obscuration of the visual fields, the latter clearing up as the pulsation diminished or ceased, which may occur within the hour. In the later stages of the disease there is no remission of symptoms, the violent glaucomatous symptoms becoming permanent, and vision hopelessly destroyed. Contraction of the visual field, particularly at the nasal side, is present, and becomes more marked with each succeeding attack. Acute glaucoma in the majority of cases affects but one eye at a time, and is attended by swelling and edema of the lids, congestion of the conjunctiva, prominence of the episcleral veins, and pericorneal injection.

As the glaucomatous attacks increase in frequency the cornea becomes comparatively insensible to touch, showing less reaction when lightly touched than the normal eye.

Glaucoma is usually attended with pain, which is especially pronounced in those cases in which the intra-ocular tension is high. It is located in the eye, and also distributed over the branches of the fifth cranial nerve. It is difficult to alleviate this pain by local treatment, but if it is attempted, such drugs as eserin, which diminish the tension, should be employed.

High intra-ocular tension persists even after vision has been totally destroyed, and may cause atrophy of the iris, opacity of the lens, and ulceration of the cornea. The characteristic cupping of the disk common to all forms of glaucoma increases with the increase of tension.

Hemorrhages into the anterior chamber of the eye are very apt to occur. Later there is staphylomatous bulging of the sclerotic in the ciliary region, or farther back; and, finally, such eyes may develop acute purulent choroiditis, and the disease end in *phthisis bulbi*.

Glaucoma Absolutum.—The terminal stage of acute glaucoma is known as *absolute glaucoma*. There is no sharp line separating this stage of the affection from those preceding it, but

absolute blindness in addition to the other symptoms may be taken as an indication of its presence. The congestive phenomena are absent, with the exception perhaps of a zone of pericorneal injection or dilatation of the episcleral veins, and nothing remains to show the presence of the previous inflammatory condition. The insensibility and haziness of the cornea often persist. Vesicles may form on its surface that may become perforating ulcers. The pupil is dilated and immobile and is filled by a greenish reflex. The iris is shrunken and discolored, and at the margin of the pupil on the iris will be found a border of dark pigment. The anterior chamber remains shallow and tension is increased. The pathological cupping of the disk becomes greater and atrophy of the optic nerves supervenes. The increased tension may also induce staphyloma of the sclera.

The increased tension, the weakening of the coats of the eye, the vascular disturbances, etc., all tend to impair the nutrition of the eye, so that after a while degeneration begins. This is manifested by the corneal ulcerations, staphylomata of the sclera, retinal detachment, lenticular opacities, various subjective phenomena of light, atrophy of the optic nerve, shrinking of the globe, etc. An eye undergoing degeneration after glaucoma is also liable to become the seat of iridocyclitis or panophthalmitis as the result of corneal perforations from the most trivial forms of ulcers.

Glaucoma fulminans is a less frequent variety of acute inflammatory glaucoma that is characterized by an absence of premonitory symptoms or periods of remission. It occurs less frequently than the other varieties of glaucoma, and runs its course in a very short time. The onset of the affection is extremely acute, and the symptoms are more severe than in the ordinary acute form, and blindness may follow within a few hours.

Subacute glaucoma, while not a distinct variety of the disease, is applied to the attacks that precede or succeed an acute attack, and is often described in conjunction with the chronic congestive variety presently to be discussed. It is characterized by exacerbations and remissions of less intensity than in acute glaucoma, but without complete relief at any time. The symptoms which may occur for many months are essentially the same as in other primary forms of the affection, and eventually terminate in acute or chronic glaucoma.

Chronic Glaucoma.—Glaucoma may begin as a chronic affection (see below), or it may develop insidiously from the constant repetition of mild acute or subacute attacks (*chronic congestive glaucoma*). The premonitory attacks become more and more frequent and continue for a long period, and the intermissions are of shorter duration, until finally no intermissions are observed, and the disease gradually and almost imperceptibly merges into chronicity. There may be no pain in the eye at any time in this variety of the disease, and the patient may only become aware of its existence after vision has been greatly impaired or blindness has occurred.

Perhaps the first symptom that will attract the attention of the observer will be the marked failure of accommodation, necessi-

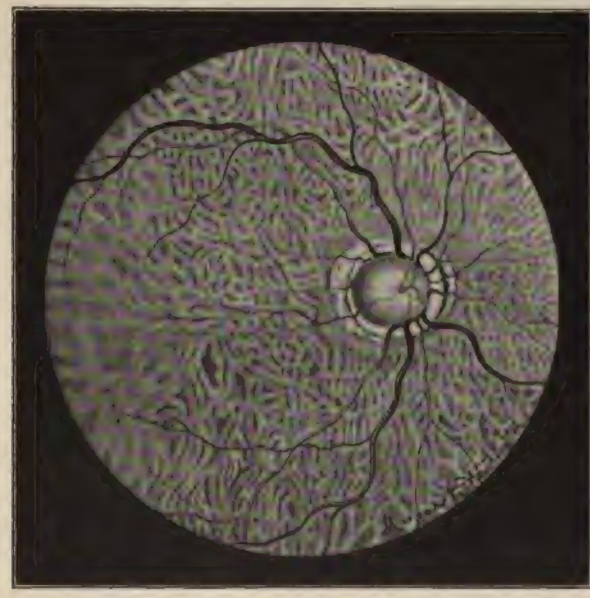


FIG. 166.—OPHTHALMOSCOPIC APPEARANCE OF CHRONIC GLAUCOMA, SHOWING DEEP EXCAVATION OF OPTIC NERVE.

tating the frequent changing of the presbyopic lenses. A careful examination of the exterior of the eye at this time will show increased intra-ocular tension, which progresses until stony hardness is reached, dilatation and tortuosity of the subconjunctival veins, haziness and lessened sensibility of the cornea, shallow anterior chamber, sometimes atrophy of the iris, dilatation and

impaired motility of the pupil, etc. Pain is frequently absent. In addition to impairment of vision there will be found contraction of the visual field, most marked toward the nasal side, or a portion of the visual field may be partially obscured.

Ophthalmoscopic examination reveals considerable cloudiness of the media, so that it is often impossible to distinguish the details of the eye-ground. In such cases the indirect method will be found extremely useful. The optic nerve presents the characteristic glaucomatous cup that is pathognomonic. The excavation of the nerve head involves the entire disk, and has steep overhanging edges over which the blood-vessels bend sharply and are lost to view to reappear in the bottom of the depression. The depth of the cup may be ascertained by noting the difference between the refraction of the edges and that of the center of the papilla. The retinal veins are widely dilated and tortuous, while the arteries are contracted and possess an abnormal pulsation peculiarly characteristic of this disease.

Chronic Noninflammatory or Simple Glaucoma.—This affection was for a long time considered distinct from glaucoma, with which it was supposed to have nothing in common but the excavation of the optic nerve, and it was originally described by von Graefe under the title of "amaurosis with excavation of the optic nerve."

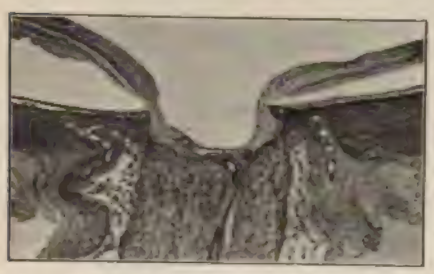


Fig. 167.—Longitudinal Section of Nerve, Showing Glaucomatous Cup. (Elschnig.)

It is characterized by an entire absence of inflammatory phenomena or pain, and the diagnosis is made from the ophthalmoscopic appearance and the abnormal increase in the intra-ocular tension.

In the majority of cases the course of the affection is exceedingly slow and its gravity may fail to be recognized by the patient until well advanced by reason of its insidious onset. There is an entire want of prodromal symptoms, and the only complaint the patient makes is an inability to perform close work at a comfortable distance. This weakness of sight tends to increase, and

reading, sewing, writing, etc., become impossible. This is confused by the laity with the normal failure of accommodation incident to advancing age, and the patients consult refracting opticians, with whom the true nature of the affection is equally vague. The convex lenses prescribed for the presbyopia under these circumstances fail to retard the progress of the disease and are of no value whatever.

Externally the eye may appear normal. The refracting media may be quite clear; the cornea may remain sensitive; the depth of the anterior chamber may be unaltered; and the iris may be normally or only slightly discolored. Comparison with the unaffected eye is always necessary in these cases to detect minor differences. The pupil in some cases is dilated to a moderate degree and reacts rather sluggishly. The tension may or may not be elevated, but an increase is not constant. Examination of the fundus reveals the presence of the characteristic cupping of the disk and arterial pulsation. Examination of the visual field shows the usual contraction most marked toward the nasal side.

The affection is essentially chronic from the start, and at no time is there any inflammatory reaction. With the increase of tension the excavation of the papilla becomes deeper, and atrophic changes in the optic nerve, blood-vessels, and ocular tunics take place. The field of vision is contracted to a corresponding degree, and complete blindness supervenes as the atrophic process progresses. The condition begins as a unilateral affection, but both eyes are frequently involved before the completion of its course.

Secondary glaucoma is that variety which is directly traceable to some other ocular condition. It always follows some pathological condition of the eye that results in obstructing the angle of the anterior chamber. Among these may be mentioned iritis and its sequels, congenital absence or coloboma of the iris, serous cyclitis, anterior synechiæ of the lens capsule, or hyaloid membrane of the vitreous after cataract extraction, wounds and luxation of the crystalline lens, intra-ocular tumors, cysts in the anterior chamber, retinal detachment, thrombosis of the retinal vein, hemorrhagic retinitis, etc.

Glaucoma occurs occasionally after retinal hemorrhage, and is characterized by symptoms similar to those of acute inflammatory glaucoma with the addition of the extravasation of blood into the

media and tunics (hemorrhagic glaucoma). The affection presents itself in from two to eight weeks after the retinal hemorrhages, and tends toward absolute blindness in spite of the most prompt treatment.

Secondary glaucoma also occurs in connection with intra-ocular tumors, adhesions of the iris to the lens or cornea, injuries and luxation of the crystalline lens, etc. Elevation of tension may occur in a number of affections, but can only be considered glaucomatous when vision is impaired, the disk abnormally excavated, and the visual field coincidently contracted. The termination of secondary glaucoma differs in no respect from that of primary glaucoma.

DIAGNOSIS OF GLAUCOMA

Glaucoma, on account of its various forms, is liable to be confused with a number of ocular affections (see table, page 257), but a distinction can usually be made by noting the presence or absence of increased tension with pathological cupping of the nerve and arterial pulsation. Either of these symptoms may exist in connection with less serious affections, but their combination is pathognomonic of glaucoma.

It is therefore of great importance to ascertain the tension in all cases as a routine procedure, and this is best accomplished by palpation. The patient should be directed to look downward, and the index-fingers are lightly placed upon the closed lid immediately beneath the supra-orbital arch, the remaining fingers resting upon the forehead or temple. Pressure is then exerted alternately by the fingers and the tension estimated.

For convenience, the letter T has been adopted as the symbol for normal intra-ocular tension. T + ? denotes a doubtful increase of tension; T + 1, T + 2, and T + 3 indicate the three varying degrees of hardness of the globe—T + 3 denoting stony hardness. The minus sign, with the same figures, indicates diminished pressure, T — 3, for example, indicating a perfectly flaccid condition of the globe.

Comparison with the tension of the unaffected eye is always necessary, as well as with the normal eye. The method is only relatively accurate and requires considerable practice for precision.

The pain and increase of tension in spasm of accommodation in connection with an unusually deep physiologic cupping of the optic disk may mislead the casual observer, particularly if the media are somewhat hazy and high errors of refraction are present. Such cases occur in comparatively young individuals, and are unassociated with any disease of the iris, lens, or retina. The vision improves with the proper correcting lens and the visual field remains unaltered.

Glaucoma may be mistaken for iritis, particularly if there is an increase of tension in the latter affection. In iritis, synechiæ may be demonstrated and the depth of the anterior chamber will remain normal. Ciliary injection and photophobia will be marked, and careful examination of the cornea by oblique illumination will show the presence of dotted opacities on the posterior layer of that structure. The history, age, course, and underlying cause will aid greatly in differentiating these conditions.

Conjunctivitis has been mistaken for acute glaucoma when the cornea has been involved at the same time. The tension may be elevated in conjunctivitis, but is not constant. The pupil is normal and the iris is unaffected. A clear view of the fundus will reveal absence of the characteristic cup and arterial pulsation.

Cataract may be confused with glaucoma on account of the peculiar greenish reflex that fills the pupil, and by ancient writers these affections were considered but subdivisions or varieties of the same condition. Recourse to the candle-flame test of Sanson will show the presence or absence of lenticular opacities, while ophthalmoscopic examination of the fundus will reveal the presence or absence of the cupping of the optic nerve and the arterial pulsation.

The atrophy of the optic nerve common to the later stages of glaucoma may be taken for the original condition and cause of the visual impairment and contraction of the visual field. In optic atrophy there is no increase of tension, the fields are uniformly contracted and central vision is diminished to a greater extent. Pain and inflammatory symptoms are absent. The cupping in optic atrophy is more shallow and gradual than that in glaucoma. Color-blindness and scotomata are more common in optic atrophy.

Presbyopia may be differentiated from the failure of accommodation found in glaucoma by the absence of such concomitant

symptoms as contraction of the visual field, increased tension, dilated and sluggish pupils, cupping of the optic disk, etc. The failure of accommodation in glaucoma is not relieved by the wearing of convex lenses, as in presbyopia.

Glaucoma is attended by anesthesia and cloudiness of the cornea in addition to the other characteristics previously mentioned, and this may serve to render the diagnosis easy in obscure cases. To determine the sensitiveness of the cornea the eye should be directed upward and outward or upward and inward so as to deflect the visual axis. The cornea is then touched with a small pledget of cotton or silk, and under normal conditions this irritation is sufficient to cause spasmodic closure of the lids.

The diagnosis of the different varieties of glaucoma is more difficult on account of the frequency with which these varieties run one into the other. Acute inflammatory glaucoma is always of rather short duration, and is attended by pain and other symptoms of acute inflammation. These characteristics will serve to distinguish it from chronic glaucoma, in which the onset is insidious, the course slow, and periodic exacerbations and remissions are frequent. Pain is not severe, and the inflammatory reaction is at no time intense. Subacute glaucoma possesses features common to both these forms, and is differentiated only by exclusion. Absolute glaucoma is frequently present when the patient presents himself to the ophthalmic surgeon, and its recognition is important on account of its prognostic significance. It is characterized by blindness in addition to the other symptoms of glaucoma with atrophic changes in the optic nerve, retina, sclera, iris, and lens. Inflammatory symptoms are absent in uncomplicated cases, and pain is usually absent. Hemorrhagic glaucoma is easily distinguished from the other varieties by the retinal hemorrhages that precede it and by its sudden onset and short course.

Secondary glaucoma is seldom difficult to diagnose on account of the prominence of the underlying conditions. The conditions already mentioned, which are liable to be complicated by secondary glaucoma, should always be carefully watched during their course, as an increase of tension is always suggestive of the onset of glaucoma. Frequently it is impossible to obtain a view of the fundus, and the increased tension, pain, etc., then become diagnostic.

TREATMENT OF GLAUCOMA

The treatment of glaucoma may be conveniently divided into nonoperative and operative.

Nonoperative Treatment.—This is general and local. The constitutional measures recommended include rest, abundance of sleep, interdiction of close work, correction of any ametropia present, moderation in eating and drinking, regulation of the bowels, and the avoidance of any of the causes that have been considered as predisposing to the condition. The salicylates and iodids should be administered if there is any reason to suspect the presence of rheumatism or gout. Locally, the instillation of myotics, such as eserin and pilocarpin, have been found extremely valuable. Eserin sulphate is employed in solution in the strength of 1 grain (0.06) to 3 drams (12.0), while pilocarpin hydrochlorate is used in the strength of $\frac{1}{4}$ (0.016) to $\frac{1}{2}$ (0.03) grain to 2 drams (8.0) of distilled water.

In normal eyes the instillation of myotics or mydriatics in the eye produce no appreciable alteration in tension, but if there is any pathological condition of the iris or anterior chamber their improper application is productive of disastrous results. The use of atropin in an eye predisposed to glaucoma by the presence of some obstruction in the angle of a shallow anterior chamber will increase the tension to a great degree and precipitate an attack of primary glaucoma, which may be aborted and the tension reduced to normal by the prompt instillation of eserin.

Myotics influence tension by drawing the iris, during the contraction of the pupil, away from the angle of the anterior chamber and opening out the iris crypts of Fuchs. They are of value only when the iris is in a perfectly healthy condition. They are useless when the sphincter muscle is paralyzed from pressure on the ciliary nerve, as in some acute cases of glaucoma, and when the iris is atrophic and adherent to the cornea or lens, as in cases of long duration. It can easily be seen from the foregoing that myotics find their greatest field of usefulness in the prodromal stages of glaucoma, and will aid greatly in cutting short the duration of the attack in the absence of structural changes in the iris. Unfortunately, the greater number of cases are seen when further developed, and myotics can be considered only as palliative measures.

In the employment of eserin considerable hyperemia of the

conjunctiva and ciliary congestion and pain are sometimes induced, so that strong solutions should not be used. The combination of cocain with eserin is less disagreeable. Pale-red solutions are still efficient, but a deeper red discoloration indicates decomposition and rejection of the solution.

Morphin is often used in glaucoma to lessen the pain, and it must be remembered that its benefit is derived partly from its myotic action.

Operative Treatment.—This consists of *iridectomy, paracentesis, sclerotomy, removal of the superior cervical ganglion of the sympathetic, cyclodialysis, enucleation,* and *resection of the optic nerve.*

Iridectomy for the relief of glaucoma was first performed by von Graefe in 1856, and differs from the ordinary iridectomy in several respects. It has for its object the opening up of the filtration area at the angle of the anterior chamber. In order to accomplish this purpose it is necessary that the incision should be as far back in the sclerotic margin as possible without injuring the ciliary body. The keratome should enter the anterior chamber, and a wide portion of the iris be removed. It is still the best operative procedure.

In cases where the intra-ocular tension is + 1 or higher the operation should be performed under ether anesthesia, but in cases in which the tension is lower cocain may be used, but should be preceded by three or four instillations of the eserin solution, gr. j (0.06) to ℥iij (12.0), or until the pupil has become contracted to the size of a pin-point. The painful portion of the operation is the withdrawal and excision of the iris.

The instruments used in this operation are an eye speculum, fixation forceps, a large curved keratome, iris forceps, and De Wecker iris scissors. The ordinary Graefe cataract knife is preferred in this operation by some ophthalmic surgeons, but it is a dangerous instrument in these cases. The incision should be made from above, as the coloboma of the iris is less disfiguring and less troublesome in this situation than when made below. The upper eyelid acts as a movable diaphragm in such cases and prevents the entrance of any excess of light. The conjunctiva is grasped at its inferior corneoscleral margin by fixation forceps and the eyeball is firmly held in any desired position. The eyeball

is rolled downward as far as possible, and held there by means of the fixation forceps (Fig. 168). The keratome is inserted from one half to one and a half lines behind the cornea and to one side of the vertical axis of the eye. The instrument is pushed into the anterior chamber until the point is opposite the lower margin of the pupil, after which it is withdrawn, making an outward and upward sweeping incision. The iris usually bulges out through this incision. The iris forceps, closed, are then inserted through the incision and advanced to the pupillary margin slightly to one side of the median line, where they are opened. A portion of the iris is grasped by closing them and is carefully withdrawn through the scleral wound. As the iris is thus held up it is divided close to its base by three cuts with the De Wecker scissors, the lower blade of which is inserted beneath and within the edges of the corneal wound. The first cut is made by directing the point of the scissors toward the base of the iris, the second by having the point and blades parallel to the base, and the third by directing the point downward and outward from the base with which the heel of the scissors is in contact. The cutting should be performed entirely by the descent of the upper blade upon the lower blade, and the latter should remain stationary. The excision of the iris is greatly facilitated by gently drawing it in a direction opposite to that in which the incision is being made by the scissors, being careful to avoid tearing it. The object of the three incisions is to form a large keyhole pupil, which is a *sine qua non* for a successful result. It is very important to see that all the remaining portions of the iris are carefully replaced, and for this purpose a delicate tortoise-shell spatula may be used. A drop of weak atropin or homatropin solution may be dropped into the eye to insure wide

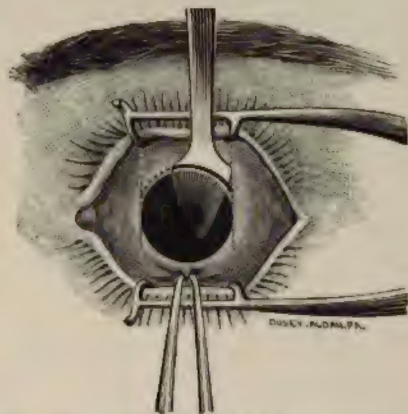


FIG. 168.—IRIDECTOMY FOR GLAUCOMA, SHOWING THE MANNER IN WHICH THE KERATOME SHOULD BE INTRODUCED.

dilatation of the iris. I have never experienced any untoward results follow, such as iritic adhesions, etc., in using these drops after this operation. Immediately after the operation the tension should fall, and the absence of such an occurrence is of unfavorable significance. A bandage should be worn until the anterior chamber reforms. This may be delayed for a week or more, or it may be preceded by an increase of tension. Occasionally

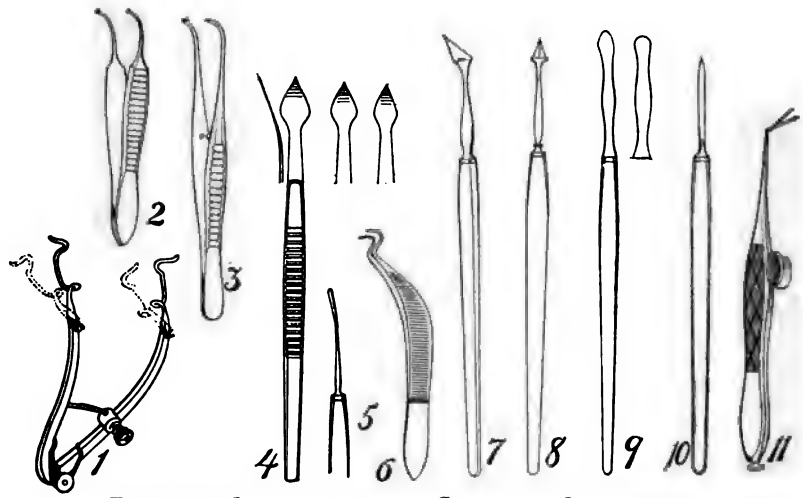


FIG. 169.—INSTRUMENTS FOR GLAUCOMA OPERATIONS.

1. Author's speculum. 2 and 3. Iris forceps. 4. Landolt's keratomes. 5. Spatula used in cyclodialysis. 6. Kuhnt's forceps. 7. Angular keratome. 8. Paracentesis needle. 9. Desmarres' knife (used by author for making scleral incision in cyclodialysis). 10. Von Graefe's knife. 11. De Wecker's scissors.

after iridectomy the case may assume a malignant character, in which the lens is pushed forward and blocks the wound and the angle of the anterior chamber.

To be of value iridectomy should be performed before vision is much impaired, and while there is still sufficient space between the iris, sclera, and cornea to permit the making of an incision in the iris angle. It should effect the removal of a portion of the iris at its place of attachment to the ciliary body so that no stump remains.

Statistics show that iridectomy is most successful in acute cases of primary glaucoma, in which there is apposition of the iris to the cornea but very little adhesion of the apposed surfaces. When iridectomy is performed in such a case the iris is torn away

at the extreme periphery of its base. The longer the iris is apposed to the cornea, the greater is the adhesion. The knitting together of iris and cornea is so intimate that the iris would tear away at the false angle—i. e., the anterior border of the adhesion. This accounts for the failure of iridectomy to relieve some of these cases.

The more intense the symptoms and the more marked the increase of pressure the more extensive should be the incision of the iris, and it is important to bear in mind that the aqueous humor must be very cautiously evacuated, because a too sudden relaxation of the pressure may cause extensive hemorrhage into the internal membranes and cavities of the eye. In the nature of the disease itself there is a great tendency to rupture of the blood-vessels.

An examination of iridectomized eyes reveals the fact that in many instances the iris has not been removed up to its extreme periphery, and in the unrelieved cases the portion of iris which is left blocks up the filtration area and sometimes a cut edge becomes entangled in the scar.

Treacher Collins, after examining several iridectomized eyes, states that it is very rare for the section to pass through the ligamentum pectinatum, and that the canal of Schlemm invariably escapes. He found that the corneoscleral incision was always oblique so that the extent of the external wound afforded only an imperfect criterion of the position and extent of the internal wound. This may account for the failure of later iridectomy in chronic glaucoma to relieve abnormal tension.

In some cases it seems to have been successful in restoring filtration by creating a permeable cicatrix, for it has been shown that microscopic fistulæ do actually occur and can be demonstrated in some iridectomy scars.

Paracentesis of the anterior chamber is occasionally employed in glaucoma as an emergency operation. It affords but temporary relief, the tension becoming again high as the fluid accumulates. It is of most value in glaucoma secondary to iridocyclitis, and in those cases in which the anterior chamber is deep and its contents excessive.

Sclerotomy or incision through the sclera may also be performed in glaucoma, but is of less value than iridectomy. The

scleral incision may be made in front of the iris (anterior sclerotomy) or behind the ciliary body (posterior sclerotomy).

Anterior Sclerotomy is preferred in most cases. A Graefe knife should be entered about 1 mm. external to the corneal margin and carried across the anterior chamber, emerging in the sclera at a corresponding distance from the corneal margin. These points should be on a line 2.5 mm. from the superior margin of the cornea.

The knife is then drawn back and forth with a sawing motion two or three times, after which it is slowly withdrawn, allowing the aqueous to escape before the flap has been completely cut, leaving a bridge of conjunctiva and sclera between the first and last cuts. The instillation of eserin before and after the operation will prevent any tendency toward prolapse of the iris. Cutting through the base of the iris, or the excision of a portion of it, is sometimes performed in addition. The benefit derived from sclerotomy may be due either to the formation of cicatricial tissue at the sclerocorneal margin that allows filtration of the ocular fluids through it, or to a fistulous condition following a cystic scar at the wound margins. Its results are never certain, and it is inferior to the operation of iridectomy.

Posterior Sclerotomy consists in an incision of the sclerotic and vitreous 1 mm. in depth by means of a Graefe knife. The conjunctiva is drawn to one side so as to cover the scleral wound at the conclusion of the operation. The knife is entered at a point 7 mm. behind the corneal margin and between the external and inferior recti muscle, care being taken to avoid the ciliary body. As the instrument is withdrawn it is rotated slightly to allow gaping of the wound and escape of fluid. The result is only temporary, as the scleral wound heals within a short period and the tension again becomes high.

The operations of Lagrange and Herbert for the cure of chronic glaucoma, based upon the theory of establishing permanent drainage, either by a filtration cicatrix or a fistulous opening in the sclera, appear to have yielded some excellent results, but more cases need to be reported before their value can be fully estimated.

Lagrange Operation.—Lagrange, of Bordeaux, endeavors to obtain a filtering cicatrix without including the iris in the lips

of the wound. This he believes he has succeeded in doing by an operation of combined iridectomy and sclerectomy (sclerecto-iridectomy).

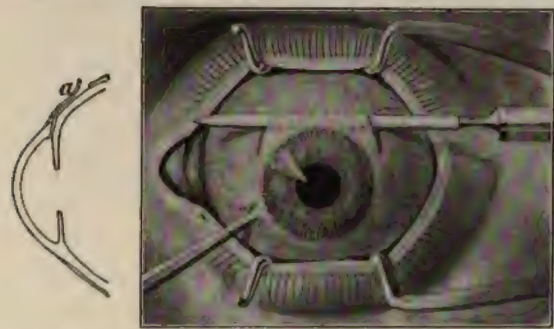


FIG. 170.—LAGRANGE OPERATION FOR GLAUCOMA, SHOWING SCLERAL INCISION, AND CONJUNCTIVAL FLAP.

a. Line of scleral incision in profile.

About half an hour before operation a few drops of eserin are instilled in the eye. Shortly before the operation cocain and adrenalin are dropped into the eye several times to produce complete insensibility of the iris and obvious ischemia of the mucous membrane.

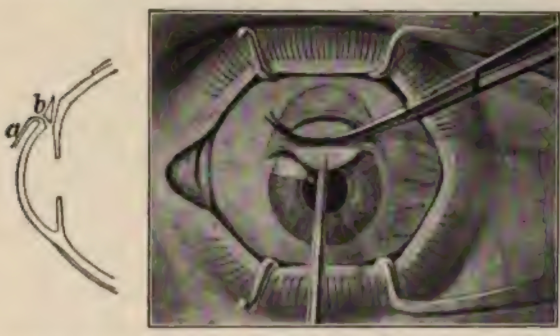


FIG. 171.—SECOND STEP IN LAGRANGE OPERATION, SHOWING CONJUNCTIVAL FLAP DRAWN FORWARD, AND EXCISION OF SCLERA WITH SPECIALLY DEVISED (LAGRANGE) SCISSORS.

a. Flap drawn forward (in profile). *b*. Excised sclera.

In addition to the instruments ordinarily required for iridectomy is needed a small pair of curved scissors which should be very sharp.

In the first stage the sclera is punctured with a Graefe knife at a distance of 1 mm. from the limbus, and the counter puncture is made at a corresponding point (Fig. 170). The sclera is divided upward in the iridocorneal angle. In terminating the inci-

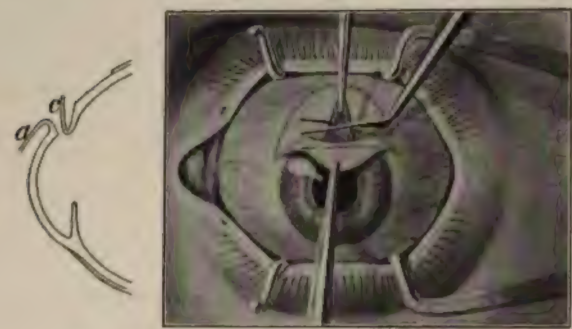


Fig. 172.—The Iridectomy in Lagrange Operation.

sion the cutting edge of the blade is directed backward in such a way as to bevel the sclera. When the knife is beneath the conjunctiva, a large conjunctival flap is made. In the second stage the conjunctival flap is raised by means of toothed forceps and

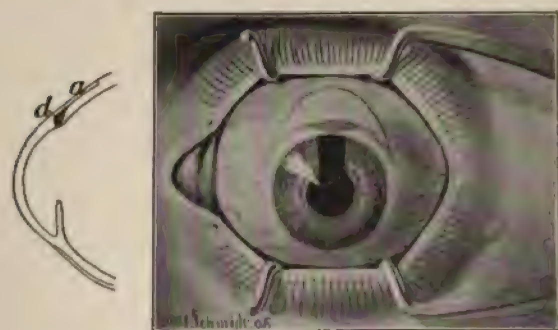


Fig. 173.—Lagrange Operation Completed.

a. Conjunctival flap replaced. *d*. Point of excised sclera, the subsequent filtering cicatrix.

a sufficiently large piece of the sclera is cut from the exterior lip of the incision (Fig. 171). In the third stage iridectomy is performed in the usual way (Fig. 172), and finally the conjunctival flap is used to cover the wound (Fig. 173).

In his most recent paper upon the subject Lagrange states that

in those cases where the tension is from normal to one (feeble) simple sclerectomy should be practiced after the careful employment of adrenalin, eserin, and cocain, but in cases where the tension ranges from one to three sclerecto-iridectomy is indicated. Simple sclerectomy is precisely the same as the first two steps of the operation first described. The sclera is incised as far as possible from the cornea, the knife being kept in front of the iris. It is not necessary to cut a large flap; an incision of 4 mm. will suffice. After having made the puncture and counter puncture, the Graefe knife enters the tendon of the ciliary muscle which it divides, and opens largely the choroidal spaces, which are thereby put in communication with the anterior chamber. After having divided the ciliary muscle, the knife cuts the sclerotic and finally detaches a large flap of conjunctiva. The strip of sclera is then excised by means of scissors from the lip of the wound.

Colonel H. Herbert endeavors to produce permanent filtration through the sclera by the "wedge-isolation" operation for the relief of glaucoma.

After the anterior chamber has been opened by a very narrow-bladed Graefe knife passed across it horizontally, a short scleral flap upward is made but left attached at its apex. Then by changing the direction of the knife edge and making two cuts forward and upward, a narrow strip of sclera is detached from the flap at the limbus. The whole procedure is subconjunctival, so that the wedge of sclerotic detached is left adhering to the conjunctiva, which holds it loosely in the groove cut in the sclera. A small buttonhole iridectomy usually is made to prevent prolapse of iris. A permeable scar is said to be the result, and not a definite scleral fistula, as Lagrange aims at producing.

S. Holth seeks to insure permanent drainage by purposely causing incarceration of a fold of the iris in the scleral wound, which may vary in length from 6 mm. to 10 mm. It is made with a Graefe knife or a keratome measuring 6 mm. at its base, with a stop to prevent its introduction a greater distance than 6 mm. No myotic should be instilled on the morning of the operation.

Holth insists upon the careful protection of the iris by a large conjunctival flap to prevent infection. He therefore commences his operation by puncturing the conjunctiva with the

Graefe knife 5 mm. above the limbus and slips the knife under it to puncture the sclera at a distance of 1 mm. from the corneal margin. The counter puncture is similarly placed. On completing the incision of the sclera the edge of the knife is turned backward so as to make a 5-mm. conjunctival flap. In some cases where he has made a 6-mm. linear incision of the sclera he rotates the eye downward and pierces the conjunctiva with the keratome 8 to 10 mm. above the corneal border. He then pushes it downward with zigzag movements between the conjunctiva and the sclera until it is 1 mm. from the corneal margin, when the scleral puncture is made, and the knife is pushed forward parallel to the iris until the incision is 6 mm. long. The incarceration of the iris is produced by catching a piece of the iris in an iris forceps and pulling it into one of the angles of the wound. To insure seizing a very small piece of iris, Holth uses a pair of forceps with a stop screw which he sets so as to prevent the blades opening more than 2 mm.

Such is the procedure where the eyes have been previously iridectomized. In several cases he has combined his operation with iridectomy.

Holth considers that although the easiest of the modifications he describes in his article is that of iridectomy, through a keratomic incision with incarceration in the two angles of the wound, the most elegant operation is that of incarceration combined with extra-sphincteric iridotomy, which leaves the pupil intact and causes a coloboma upward, which is so small as to be scarcely noticeable. His operation is not recommended in acute or subacute cases. In the early stages of chronic glaucoma, Holth is content to rely upon treatment with myotics.

Sympathectomy.—Excision of the superior ganglion of the cervical sympathetic has been shown by Jonnesco to reduce tension and induce marked contraction of the pupil. He also states that attacks of headache and other symptoms of irritative glaucoma are prevented, and that in the absence of trophic change vision improves. The ganglion may be reached by an incision over the anterior border of the sterno-mastoid muscle; the sheath of the carotid vessels should be either opened or pulled to one side and the ganglion will be exposed behind it, after which its excision may be easily accomplished by means of scissors. In addi-

tion to the results already mentioned, tachycardia, exophthalmos, and death have been reported as sequences.

Cyclodialysis.—This operation, originated by Heine, is essentially a detachment of the ciliary body, and effects a communication between the suprachoroidal space and the anterior chamber. The fundamental steps of the operation may be divided as follows, Dr. Meller's procedure being largely followed with some slight changes, especially in the after-treatment: (1) The primary incision into the conjunctiva and the capsule of Tenon, exposing the sclera; (2) the scleral incision; (3) the introduction of the spatula, or whatever instrument may be preferred for the purpose; (4) the cyclodialysis itself.

1. An incision is made into the conjunctiva down and out, and continued through the capsule of Tenon, exposing the sclera so that the latter can be incised about 5 mm. from the limbus.

2. An incision is made into the sclera 5 mm. from and parallel with the limbus, not exceeding 2 mm. in length. Various instruments have been used for executing this incision, some using a keratome, cutting with its lateral edge, others a Graefe knife. The author has found the most suitable instrument to be a modified Desmarres scarifying knife (see Fig. 169[9]). The incision should be cautiously and slowly executed so as to avoid injury to the uvea, using just enough and no more pressure than is necessary. A decrease in the resistance of the sclera, and the slightest appearance of the dark uveal tissues, are signs that the incision has been performed to a sufficient extent. Another indication that the incision has fulfilled its purpose is pain, as the scleral incision itself, if the eye has been thoroughly anesthetized (cocain), is painless.

3. The selection of an instrument for this step of the operation will largely depend upon the individual choice of the operator; essential features, however, are that the instrument has no cutting edge and that it will comfortably conform in its diameter to the length of the scleral incision, which should be large enough to accomplish the purpose of the operation and yet small enough to prevent such complications as gaping of the wound, prolapse of the ciliary body, etc. The author employs a specially devised iris spatula (Fig. 169[5]).

The scleral incision having been completed, whatever scleral fibers which remain having been carefully divided with a knife and not broken up by any other instrument, the spatula is held at right angles but not quite vertical to the scleral wound, into which it is introduced until the posterior margin of the wound has been reached; its handle is then depressed until its anterior surface is in a parallel direction with the posterior surface of the sclera, which is gradually accomplished as the spatula is guided forward, its free end finally appearing at the angle of the anterior chamber.

4. The spatula is not introduced any further than is necessary to keep in view its end in the anterior chamber. It is now gently rotated through an axis extending vertically through it and the scleral incision, gently separating the ciliary body below and above with lateral to-and-fro movements. The spatula is then slowly brought back to the position it occupied after it was introduced and carefully withdrawn. The conjunctival wound is then sutured.

The operation is not a difficult one, but at times very painful. Hemorrhage into the anterior chamber frequently follows, but it is not a serious complication, disappearing in a few days. The site of the operation should be kept as free as possible from blood, not only for the purpose of preventing an obscuration of the operative field, but to prevent the blood from entering the interior of the eyeball.

The after-treatment is rest in bed (some operators do not consider this necessary). The eyes are bandaged with a dressing saturated with the lead water, opium, etc., solution mentioned in various chapters by the author.

The avoidance of complications during the operation consists: (1) not making the scleral incision too large; (2) gentle introduction of the spatula; (3) not forcing the latter through undivided scleral fibers; (4) control of hemorrhage; (5) preventing as far as possible any injury to the posterior surface of the cornea.

Enucleation is advisable only when vision is completely lost and the eye is the seat of constant pain and irritation. It should be preceded by an iridectomy, as this operation sometimes postpones enucleation for a considerable period.

Neurectomy (*optico-ciliary neurectomy*), or resection of the optic nerve, may also be employed in painful, blind, glaucomatous eyes. The operation is performed as follows: The lids are separated by means of the ordinary speculum and a vertical incision is made through the conjunctiva over the insertion of the external rectus muscle; the conjunctiva is then dissected off as far back as the external canthus will permit. This serves to completely expose the muscle. Two silk threads are then passed through the

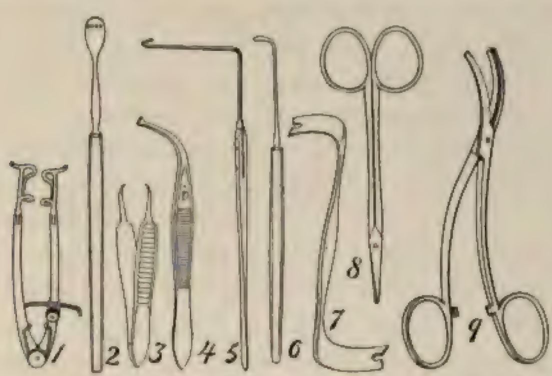


FIG. 174.—INSTRUMENTS USED FOR RESECTION OF THE OPTIC NERVE.

1. Author's speculum. 2. Carter's retractor. 3. Critchett's fixing forceps. 4. Von Graefe's fixing forceps. 5. Carter's optic nerve retractor (right and left). 6. Strabismus hook. 7. Author's duck-bill retractor. 8. Straight scissors. 9. De Wecker's compression scissors.

muscle near its tendinous insertion. The muscle is afterwards divided and drawn to the temporal side, thus exposing the globe. All tissue should be separated from the eyeball by curved scissors. A long strabismus hook, bent at a right angle, is then inserted along the globe until the nerve is found, after which it is brought forward by means of the hook. A duck-bill retractor is then passed downward until the nerve is encountered, when it is pressed down and out, keeping the adjacent tissues out of the way. A second bent hook is also passed backward and inserted under the optic nerve. A portion of the nerve is then exposed and severed by De Wecker's large curved scissors, which also controls the hemorrhage of the central artery. The eyeball is then rotated forward and a small portion of the bulbar end of the nerve is excised by means of scissors. The eyeball should be rotated into its proper place and the external muscle readjusted by

the threads previously mentioned. The conjunctival wound is also closed by sutures, which may be removed in three days. Antiphlogistic dressings should be applied twice daily for several days, but usually there is very little reaction and no disfigurement.

Choice of Operations.—*Iridectomy* is indicated in acute glaucoma as soon as the diagnosis is made, as the progressive character of the affection influences the result to a considerable degree. It is productive of best results when performed in the premonitory period between the attacks. Myotics should be employed before and the second day after the operation. General anesthesia is always necessary. In acute inflammatory glaucoma iridectomy causes rapid subsidence of the inflammatory symptoms, diminution of tension, and restoration of vision, all of which are usually permanent. Exceptionally, repetition of the operation is necessary, and still more rarely it produces no effect whatever upon acute inflammatory glaucoma. Dunn has always found the pulse tension above normal in cases of essential glaucoma, and claims, as a general rule, that the success of an iridectomy in *simple chronic glaucoma* is more favorable the nearer the pulse tension approaches the normal.

In absolute glaucoma in which the patient experiences considerable pain, iridectomy should be performed, but it affords only temporary relief, and enucleation or resection of the optic nerve is required at a later period.

In subacute glaucoma the employment of *myotics* is often productive of the desired results, and iridectomy or other operation is indefinitely postponed. Operative treatment, however, will be required sooner or later, and the sooner performed the better the result.

In chronic inflammatory glaucoma *iridectomy* serves to check the progress of the disease, lessening the tension, relieving the pain, and clearing the media, but fails to restore vision on account of the structural changes that have taken place in the eye. Sometimes there is a progressive loss of sight after the operation.

In simple glaucoma, although iridectomy is indicated, it is by no means followed by the favorable results as in acute inflammatory glaucoma. In about 50 per cent of cases arrest of the progress of the affection follows. In the remaining half the result

may be temporary, a second operation may be necessary, or the affection may assume a malignant character.

Sclerotomy is indicated when for any reason iridectomy is impossible or when a relapse has followed iridectomy. It was used in preference to iridectomy by the late Dr. De Wecker and others in selected cases of simple glaucoma, infantile glaucoma, and hemorrhagic glaucoma. It is also indicated when the iris is atrophic.

A combination of *sclerotomy* and *iridectomy* is sometimes necessary. A preliminary posterior scleral puncture is indicated when the anterior chamber is extremely shallow and the lens and iris are pressed forward to a considerable degree. Sclerotomy may be required after iridectomy when a portion of the iris is left behind and obstructs the filtration area, inducing a return of the glaucomatous symptoms.

Removal of the *superior cervical ganglion* of the sympathetic has not yet assumed its proper place in the treatment of glaucoma, and is still in the experimental stage.

Cyclodialysis.—The author has not had enough experience with this operation to form a definite judgment as to its value, although as far as his experience extends, it would appear to him that the procedure is of doubtful value, and certainly should not be performed in hemorrhagic glaucoma. As an operation of selection it could be reserved for those cases in which there is considerable intra-ocular tension, with little or practically no anterior chamber, and associated with extreme dilatation of the pupil and an atrophic iris.

PROGNOSIS OF GLAUCOMA

Glaucoma is a serious disease, and never tends toward spontaneous cure, but progresses toward incurable blindness. Iridectomy is the best mode of treatment and the best results follow its performance in the early stages, in which cure is effected. In the later stages relief is produced which is more lasting than that produced by other methods of treatment.

In this connection Mendel's[1] report from Hirschberg's Ophthalmic Clinic will be of interest:

[1] *The Ophthalmic Record*, vol. xi, No. 4, April, 1902.

Two hundred and thirty-four cases of glaucoma have been treated in this clinic during the past seven years, and 258 eyes operated on for the disease. Of this number, 144 were women, 83 men, and 7 children. In 15 cases no operation was performed.

The best results were obtained by iridectomy in acute inflammatory glaucoma, complete or partial cure being effected in 82.2 per cent of the cases. The results in chronic inflammatory glaucoma, on the other hand, were not quite so good, only 71.1 per cent of the cases being cured. Iridectomy also proved of value in cases of simple hypertension, either improving sight, or at least preventing further injury. The results obtained from this series of cases, on the whole, confirm those obtained in 569 previous operations for glaucoma in this clinic.

In Haab's statistics, published a few years ago, the results are rathed lower, partial or complete cures being effected in 77 per cent of the cases of acute inflammatory glaucoma, and 71 per cent in simple glaucoma. Under treatment with myotics 40 per cent of the cases were cured.

Von Hippel's latest contribution on iridectomy in simple glaucoma: There were 74 eyes operated upon—65 iridectomies, 6 sclerotomies, and 3 combined operations (iridectomy followed by sclerotomy). After two years he noted the following results: Cures, 40 per cent; provisional cures, 14 per cent; gradual deterioration, 26 per cent; gradual blindness, 20 per cent. Early iridectomy, according to this operator, is the sovereign remedy.

Much attention has of late been directed to the comparative value and results of iridectomy and the myotic treatment in chronic glaucoma.

Posey gives an analytical study of 65 cases treated by myotics over a series of years. Visual acuity was improved in 62.16 per cent of the cases, while it remained unaltered in 21.62 per cent. In only 16.21 per cent did the vision diminish.

By way of comparison he quotes the results of iridectomy in two series of Bull's cases. In the first series (50 cases, 94 eyes iridectomized) there was a maintenance of the vision existing at the time of operation in 25.5 per cent, and gradual failure in 61.7 per cent, absolute glaucoma resulting in 11 eyes. In Bull's second series (60 cases, 115 eyes iridectomized) there was a maintenance of vision for a period of years in 18 per cent, and

gradual failure in central vision in 70 per cent. In 16 cases the final result was absolute glaucoma.

From these statistics it is evident that the myotic treatment is well worthy of consideration. The earlier the myotic treatment is commenced, the better is the result as to the probable arrest of glaucoma, and the earlier the operation is performed the earlier the arrest of glaucoma, but the difficulty lies in persuading the patient to submit to such a delicate operation in the early stages of the disease, an operation which the author is convinced is ultimately the safer procedure.

It is generally conceded that the reason iridectomy fails is that the root of the iris becomes so adherent to the back of the cornea that instead of drawing away at the extreme periphery, it draws away from it where it ceases to be adherent, and the root of the iris still blocks. The same applies to the myotics in the later stages. They fail to break down the adhesions, and therefore fail to give relief.

In the myotic treatment it is recommended that the nitrate of pilocarpin be used during the day and salicylate of eserin at night, and at least four applications should be made daily. Weak solutions should at first be used, solutions of eserin being $\frac{1}{2}$ grain to the ounce, and those of pilocarpin 1 grain to the ounce.

Mr. T. Henderson believes that myotics are beneficial in proportion as they contract the pupil and open out the existing iris crypts, while iridectomy results in making a large crypt, through which the aqueous can come in direct contact with the iris veins, opening up a permanent channel for the intra-ocular fluids to drain away.

CHAPTER XVII

SYMPATHETIC OPHTHALMIA

(Transferred Ophthalmitis)

Definition.—Inflammation in one eye as the result of some sympathetic connection with an affection in the other eye. The eye that is the seat of the primary inflammation is known as the *exciting eye,* the other as the *sympathizing eye.*

Etiology.—Sympathetic ophthalmia consists essentially of a plastic cyclitis or an inflammation of the entire uveal tract. The cyclitis present in the exciting eye is usually traumatic in origin, but may arise from other causes. The most frequent forms of injury that may induce it are *wounds of the ciliary region* incident to the entrance of a foreign body into the eye and wounds of the corneoscleral zone into which the iris and ciliary body have become prolapsed and incarcerated. It may also follow perforation of the cornea as the result of certain forms of ulcers. Pressure of long duration upon the ciliary body, such as results from calcareous formations between the retina and choroid, as well as ossification of the latter, tumors within the eye, dislocation of the lens, and bands of lymph the result of lens extraction or similar operation, may induce it. The pressure of an improperly fitted artificial eye upon a stump in which some of the ciliary nerves are embedded is also said to be a cause. The exciting factor is, in all probability, microörganisms introduced into the exciting eye.

Other inflammatory conditions of the eye have been said to be sympathetic in character in certain cases, but are less frequent than the plastic cyclitis following disease or injury of the ciliary body in the exciting eye. The most common of these are serous iritis, iridokeratitis, chororetinitis, spasm of the orbicularis muscle, and optic atrophy. The period requisite for the development of sympathetic disease after the receipt of the injury varies from

sixteen days to forty years, but usually the affection manifests itself in from four to eight weeks. Children and young adults seem to be more susceptible to this condition than older persons, but this is probably due to the fact that they are more exposed to its causes than others.

Symptomatology.—The symptoms may be both local and general. The onset of the affection is generally marked by such prodromes as photophobia, asthenopia (also accommodative), rendering near work irksome and distressing, lacrymation, contraction and clouding of the visual fields, various color sensations, blepharospasm, photopsia, and amblyopia, especially associated with fatigue as pointed out by Liebreich, Laqueur, and others. Pericorneal and ciliary injection, pain and tenderness in the ciliary region, and neuralgia along the course of the fifth nerve are also present. These symptoms produce the condition known as *sympathetic irritation* and as such are attended by no structural changes.

The removal of the cause of the disturbance gives rise to prompt subsidence of these symptoms, but their persistence may induce true sympathetic inflammation. There is a rapid increase in the pain, which is " shrinking " in character and is best elicited by pressure over the ciliary region, causing the patient to draw back in agony. The cloudiness of sight steadily progresses until vision is greatly reduced. The anterior chamber is deep and the iris is discolored. Frequently its first manifestation is a serous iridocyclitis, and often a slight optic neuritis may be demonstrated in the early stages. Ciliary injection and tenderness are marked and the media become extremely hazy. Vitreous opacities are common. The pathological distinction of the two affections has yet to be definitely determined. Oscillating movements of the pupil may be detected, and are said to indicate the evolution of *sympathetic irritation* into true *sympathetic inflammation.* A plastic exudate soon forms as the result of the intensity of the inflammation in the sympathizing eye with posterior synechia, occlusion of the pupil, and retraction of the base of the iris in consequence. At the beginning of the disease the intra-ocular tension is above normal, but later becomes diminished as the exudate shrinks. Atrophy of the vitreous with prolapse of the retina, cataract, phthisis bulbi, and blindness follow at a later

period. Preceding the development of the symptoms there may be iritis, iridocyclitis, and congestion of the exciting eye, although none of these local manifestations can be designated as characteristic.

The general symptoms are also of importance. Intense headache with delirium, fever, and sometimes deafness, often suggest meningitis. It has therefore been urged to investigate the blood, secretions, and general physical condition of patients suffering from sympathetic ophthalmia.

These pathological changes do not always follow in rapid succession, except in marked cases; usually the various stages are separated by periods of apparent improvement, to be followed shortly by relapses, each relapse being a step nearer incurable blindness.

From a clinical standpoint, sympathetic inflammation is well understood, and the significance of its various phenomena is recognized by all ophthalmologists, but its pathogenesis is the subject of considerable discussion. Mackenzie believed that the inflammation traveled along the optic nerve to the chiasm, and from thence to the optic nerve and eye of the other side. The ability to produce sympathetic disease in eyes the subjects of optic atrophy seems to disprove this theory. Deutschmann assumed that the inflammation followed the lymph channels surrounding the optic nerve to the chiasm, and from thence down the channels surrounding the optic nerve of the opposite side. This observer at least proved the continuity of the transmission (ophthalmia migratoria) in the case of animals by injecting pyogenic microorganisms into one eye and producing involvement of the other eye, and subsequently recovering the bacteria in the sheaths of both optic nerves. These experiments, however, were conducted on animals and still remain to be confirmed on the human subject. It has also been suggested that the inflammation spreads along the ciliary nerves, and by their innumerable ramifications is transmitted to the ciliary nerves of the opposite side. The influence of the ciliary nerves in the production of the disease is undoubted, as it seldom arises in the absence of injury or disease of the ciliary body. The manner in which they accomplish such results, however, has not been satisfactorily demonstrated. While such inflammation has been found by Schmidt-Rimpler, Goldzieher,

Uhthoff, and others, after the process had been fully developed in the exciting eye, we are yet without proof that the ciliary nerves of the sympathizing eye, as Parsons quotes, are the seat of primary incidence of inflammation.

The recent advances in bacteriology seem to confute these theories, as it has been shown that all diseases of this character are due to the effect of microörganisms proliferating upon suitable soil. Consequently this disease is not an exception, and is produced by pathogenic bacteria as yet undescribed. Their means of conduction to the sympathizing eye also lacks satisfactory explanation, but it is probable that they infect, by means of their toxins, the lymph current traversing the channel described in Deutschmann's theory. It is also held by some that the bacteria enter the general circulation, traveling through the entire body, but fail to encounter a suitable culture medium for their growth until the eye, afterwards known as the *sympathizing eye*, is reached. In the latter theory it would not be difficult to precipitate a general pyemia if the health of the patient were below par in any respect. This theory is furthermore strengthened by the facts that sympathetic ophthalmia has occurred even after the removal of the exciting eye, from which it can be inferred that the agent causing the sympathetic involvement has already gained access to the general economy.

Prophylaxis and Treatment.—As there are two organs in different stages of a malignant inflammation depending upon some connection existing between them, it has been advised to sever this connection by enucleation of the first eye affected or by cutting the ciliary nerves. This allows the eye known as the *sympathizing eye* to easily resist and overcome the morbid processes about to develop in it. Prior to either of these procedures attempts should be made to locate any foreign body in the eye by the X-ray or other means, and, if possible, to remove it, especially if the eye is injured by a fragment of steel, etc. If the foreign body is successfully removed the ocular condition should be carefully watched for twenty-four hours. If the efforts to remove it are fruitless either of the two operations just decided should be considered. Cutting the ciliary nerves by the method of Snellen (severing them posteriorly before entering the eyeball) is theoretically applicable, but clinical experience fails to demonstrate

its efficacy in checking the progress of the disease. Enucleation is the most valuable operation in that it offers the greatest hope for cure, but before its performance is decided upon the relative condition of the two eyes should be carefully considered. Not infrequently, by delay, often unavoidable, the disease has so far progressed in the *sympathizing eye* that it is of less value as a visual organ than the *exciting eye.*

This emphasizes the necessity of prompt treatment in such cases, and as a guide to treatment the following rules will be found extremely useful:

1. Complete blindness with pain and sensitiveness to pressure in the *exciting eye* indicates its removal at once, particularly if the patient resides some distance from the hospital or an ophthalmic surgeon. In case of refusal upon the part of the patient, he should be warned of the consequences and instructed to return at once if the symptoms persist and tend to progress. In eyes blind as the result of destructive inflammation at some time previous, and which are quiet in every respect, the patient should be warned of the probability of sympathetic inflammation and instructed to seek skilled aid at the first symptom of irritation in either eye.

2. The presence of a foreign body that has resisted attempts at its removal in an eye painful and extremely sensitive to pressure indicates removal of that eye even if vision is comparatively good, as blindness is inevitable as the result of the purulent inflammation which nearly always follows. Encapsulation of a foreign body is extremely rare, but has occurred in the author's experience.

3. The occurrence of injury or a perforating wound of the ciliary body with marked diminution of vision is always followed by cyclitis, and the close relation between this disease and sympathetic inflammation demands enucleation of the injured eye in such cases.

4. The appearance of the irritative stage of sympathetic inflammation in an injured eye calls for removal of the *exciting eye* at once. If the exciting eye possesses good vision and is comparatively quiet the expectant treatment should be followed up for a short period; meanwhile the degree of diminution in visual acuity in each eye should be compared at frequent intervals. A

further loss of vision indicates immediate removal of the exciting eye.

5. In cases in which the patient is seen during the height of the sympathetic disease it is perhaps best to wait for a subsidence of the inflammation to determine which is the better eye as regards visual acuity, as sometimes the *exciting eye* retains the most vision. The application of hot compresses and the instillation of cocain with atropin will serve to lessen the pain to some extent, but usually morphin is necessary. Subconjunctival injections of corrosive sublimate and normal salt solution have been recommended highly in this condition.

6. An injured eye with good vision and the absence of any inflammatory symptoms contraindicates immediate enucleation.

General Treatment.—In all cases the patient should be placed at absolute rest in bed in a darkened room, leeches should then be applied to the temple, and mercurial inunctions freely employed. It has been the author's experience for a number of years that the administration of quinin and especially of salicylate of sodium in large doses is of great value. The beneficial influence of the large doses of salicylates in sympathetic ophthalmia is a therapeutic fact, and the profession is no little indebted to Harold Gifford, of Omaha, for advocating this important part of the therapy. Gifford has found that the average patient will tolerate from 7 A.M. to 10 P.M. 1 grain to each pound of body weight.

Debilitated subjects require tonics and alteratives, as the chlorids and iodids of iron, as well as arsenic and mercury, according to the indications.

Relaxation of accommodation by the instillation of atropin should never be neglected, as occasionally sympathetic irritation is simulated by a partial spasm of accommodation. Hot applications are of value.

Evisceration or amputation of the anterior segment of the globe through the ciliary region has been performed with success in a number of instances. It should be followed by a thorough curetting of the contents of the eye, leaving the sclera only intact. Antiseptic douches should be freely employed to irrigate the cavity remaining. This operation may be further modified by the insertion of a gold ball into the sclera (Mules), which is united over it by sutures (see page 526). The conjunctiva is

also brought together in like manner. A conformer is placed over the globe to maintain it in position until healing is complete, usually three days. The only objection to this procedure is the possibility of pathogenic bacteria lurking in some fold within the sclera. This is of no moment in clean cases or when the sclera is left open, as it is then in the condition of an incised abscess, but when closed this possibility should be always borne in mind, as a return of purulent inflammation may be thus caused. It has also been advised to treat an eye the subject of purulent inflammation as an abscess, bisecting it anteriorly and allowing free drainage of its purulent contents.

It is always best to remove promptly an eye suffering from panophthalmitis, as no serious complications will follow. The free-drainage method *is not advisable.*

To determine whether the operation upon the *exciting eye* will be of value to the *sympathizing eye*, careful and repeated examinations should be made of the uninjured eye as regards vision, tension, ophthalmoscopical appearances, etc., as the presence of a plastic exudate is of unfavorable prognostic significance.

After the subsidence of true sympathetic inflammation various operations will suggest themselves for the improvement of the optical condition, but under no consideration, except possibly increased tension, should they be undertaken until twelve or eighteen months have elapsed and perfect " quiet " is established. An increase of tension to a marked degree may be relieved by repeated corneal puncture or possibly an iridectomy.

An artificial eye may be worn after the tissues in the orbit have completely healed and contracted. It should not irritate the stump in any way and should produce no discomfort.

The refraction should be examined frequently, and when the error has been found to be stationary, the correction should be ordered and worn constantly.

Prognosis.—The prognosis is always grave. The most encouragement is offered by early enucleation of the *exciting eye*, but even then it is difficult to say with certainty that the *sympathetic irritation* has not already passed over into *sympathetic inflammation.* Upon time, subsequent events, and the comparative conditions of the eye, depend the wisdom of operation in selected cases.

CHAPTER XVIII

FOREIGN BODIES IN THE EYE: THEIR DETECTION, LOCALIZATION, AND REMOVAL

General Considerations.—The eyeball often resents with great vehemence the presence of a foreign body within or upon it, and while there are cases on record, as will be presently mentioned, where foreign bodies have remained within the eyeball for a number of years without causing irritation, such cases are exceptions. Whenever an injury to the eye is associated with the entrance of a foreign body the case at once becomes one of serious import, and should be managed accordingly. The discovery of the Roentgen rays has been of inestimable value to the ophthalmologist in localizing foreign bodies in the eyeball, and this, together with the various magnets that have been devised for the extraction of certain foreign bodies, has saved many eyes that would otherwise have been doomed to certain destruction. Such foreign bodies, moreover, are amongst the most fertile sources of sympathetic ophthalmia, and may be the cause of inflammatory symptoms after having remained quiescent for years. Thus in a case of Riecke a piece of stone in the iris remained quiet for thirty-two years, notwithstanding that stone is particularly liable to cause intense inflammatory reaction, attributed in some cases to chemical irritation. Numerous similar cases are on record.

Varieties of Foreign Bodies.—These are numerous. In the case of the conjunctiva and cornea they may consist simply of particles of dust, ash, cinders, emery, glass, or even minute splinters of steel. In the case of the deeper structures they may consist of pieces of *iron* or *steel, stone, wood, copper caps, shot, gunpowder,* and even *cilia* (in Arthur J. Bedell's case there was a corneal laceration with cilia in the anterior chamber (*Annals of Ophthalmology,* 1905)) and *caterpillar hairs,* the latter causing the condition known as *ophthalmia nodosa* (see Diseases of the

Conjunctiva). The eye seems to possess a peculiar tolerance to the presence of *gold* within it. This is not only true in the case of the implantation of gold spheres, in which case the intraocular contents have been removed, but even where the latter are still present, as in the case of drainage with gold wire (De Wecker). In a large series of cases the author has never seen any irritation follow the insertion of a gold ball. *Copper,* on the other hand, such as particles of that metal, caps, etc., is capable of setting up an intense inflammation and even suppuration without the introduction of bacteria, which, according to Leber, is due to chemical irritation produced by the metal, and it is therefore very uncommon for the eye to escape inflammatory reaction from this substance. When this does occur, it is due, according to Parsons, to rapid encapsulation. *Stone,* as already stated, and likewise *wood,* are particularly prone to excite inflammatory symptoms, while glass, gunpowder, small particles of shot, and even silver are not so irritating. When a piece of iron or steel has entered the eyeball after traversing a great distance, as in the case of bullets or particles thereof, the substance has frequently become sterilized by heat during its passage through the air. According to Ayres, cheap hammers are often the cause of injuries from steel fragments.

The Location of the Foreign Body.—If the impact of the foreign body is not great, and if it does not possess gross irregularities, it may lodge on the palpebral conjunctiva, either of the lower lid or under the upper lid within the retrotarsal fold, or it may become embedded in the cornea, the bulbar conjunctiva, or the subconjunctival tissue. When the latter structure is lacerated by a piece of glass, and the glass retained, intense pain out of all proportion to the injury is a cardinal symptom. For the foreign body to become embedded in the sclera itself, without perforating the same, is relatively more uncommon owing to the resistance and contour of that structure. The *anterior chamber,* on the other hand, is frequently the site of retained foreign bodies, and the latter may often become entangled in the *iris.* If the foreign body has entered the vitreous, having gained access to that structure through the cornea and circumlental space, a piece of the iris will be cut through during its passage. Foreign bodies in the *ciliary body* or in the "danger zone" are a fruitful

source of sympathetic ophthalmia. Traumatic injury to the *lens* from foreign bodies is a frequent occurrence, the opacity being produced not only by the foreign body itself, but by reason of the opening of the lens capsule, giving access of the aqueous humor to the lens.

Foreign Bodies in the Vitreous.—It is very interesting to note the numerous foreign bodies that may enter this region, and of still greater interest are the various results that are likely to follow after their entrance.

If a foreign body becomes lodged in the vitreous it very frequently causes a most severe and destructive inflammation of the tissues through which it found entrance, or with which it lies in contact. If it has entered through the cornea, this body, as well as the iris, often becomes violently inflamed; the lens, through which it must have passed, becomes greatly swollen and cataractous, thus tending further to increase the severity of the inflammation. When the foreign body lies in the vitreous and close to the retina a severe inflammation of the retina is frequently produced as well as inflammation of the choroid, which may perhaps lead to atrophy of the globe. In a short time after the foreign body has entered the vitreous the latter becomes clouded, especially in the neighborhood of the foreign body; later the foreign body becomes encysted, and the vitreous becomes diffusely clouded and filamentous opacities float about in it, thus causing a great disturbance of vision. Infection may supervene, causing destruction of the eyeball before any remedy can become effectual.

Although the unfavorable results just mentioned must be considered as possibilities in all foreign-body cases, they are not as frequent as the modern text-books would seem to indicate. In my own experience I have observed a number of cases in which the foreign body after entering the vitreous produced very little reaction, and even in the case of large bodies the results predicted have not always taken place. In one patient a needle of steel passed through the cornea, iris, lens, and vitreous and embedded itself in the posterior portion of the eyeball in the retina, where it could be easily seen by means of the ophthalmoscope. Its track was shown by a delicate line of scar tissue. When the patient came under my charge at the Medico-Chirurgical Hospital sev-

eral weeks had elapsed since the occurrence of the accident and the eye was comparatively quiet. The foreign body was subsequently located by the X-ray. In another case the patient was shot in the face, the shot entering the eyeball. Hemorrhage followed immediately and vision was reduced to the perception of hand movement at a few inches from the eye. The patient was treated by his family physician, Dr. Glendon, of Cedarville, N. J., for three weeks by the ordinary methods for combating inflammation. The vision improved during this period and continued to improve, so that when I last heard from him it was $\frac{6}{9}$ for distance, and he was able to read the newspaper with comfort. The patient was brought to me for an opinion as to the advisability of enucleation on account of the foreign body in the eye. Upon careful examination of the eye it was found that the shot had penetrated the sclerotic just above the upper line of the external muscle, a short distance in front of the equator. On extreme convergence another opening could be distinctly seen on the same line, but just behind the equator, showing by the indenture and choroidal staining that the shot had gone in and then out through the sclerotic coat and buried itself deep in the orbit. This was subsequently confirmed by the X-ray. Enucleation was, therefore, not advised.

There are still other cases in which, although the injury may be followed by severe inflammation, the foreign body will become encysted, and the vitreous humor gradually regains its transparency after the subsidence of the inflammatory symptoms. Frequently, after a foreign body has remained encysted and dormant for a number of years, it may give rise to inflammatory symptoms, which may lead to atrophy of the globe, or produce sympathetic ophthalmia.

The resistance of an eye containing a foreign body, or through which one has passed, is always lessened and requires surveillance, as it is likely to become seriously inflamed at some remote period from the most trivial cause.

Foreign bodies may become lodged in the choroid or retina, in the latter instance giving rise to detachment, degeneration, inflammation, and especially sympathetic ophthalmia.

The Localization of the Foreign Body.—The value of X-rays in detecting and locating foreign bodies in the eye cannot be too

highly estimated. It is frequently impossible accurately to locate a foreign body in the eye by simple inspection, or by an ophthalmoscopic examination. The foreign body may penetrate the eye with such force that it is driven completely through the eyeball, or it may lodge near the point of entrance, or in the interior of the fundus at a remote point, and yet not be located with the means usually at the disposal of the ophthalmic surgeon. The hemorrhage immediately following the entrance of a foreign body, the rapid change in a punctured lens, or the escape of vitreous, all assist in obscuring the media through which the interior of the eyeball may, under normal conditions, be inspected.

The laboratory experiments that have been made since Roentgenographs were first produced have resulted in making this a positive method of diagnosis, and metallic particles may now be accurately located. The work of Van Duyse, Lewkowitch (metal indicators, 1896), Hansell, Ring, Mackenzie, Davidson, Sweet, and Stern have been most valuable in gradually perfecting this method of locating foreign bodies until it is now of great practical value.

Dr. Sweet,[1] of Philadelphia, devised a most ingenious locating apparatus. This apparatus " is fastened to the patient's head and carries two steel rods, each with a ball at the end. These balls are placed at a certain distance from the eyeball, one pointing to the center of the cornea and the other to the external canthus, both parallel to the visual line and perpendicular to the plate. The skiagraphic plate shows the approximate position of the foreign body."

McKenzie Davidson also designed a method which is simpler and less expensive than that in use by Sweet. He describes it as follows:

" A loop of lead wire is fixed by sticking plaster to the edge of the lower lid, opposite a known point of the eye; the point of this wire, projecting upward, forms the landmark from which the position of the foreign body is calculated. The patient is directed to gaze steadily at a distant object in an axis parallel with the plate—that is, straight in front—and two exposures are made on the same plate with the sliding bar." The for-

[1] *Phila. Med. Jour.*, October 14, 1899.

eign body is then localized from the resulting photographic records.[1]

Dr. A. B. Kibbee, of Seattle, one of the earliest pioneers in this field of investigation, did much good work by a geometrical triangulation method, which, however, is too difficult for practical use.

The Author's Localizer.—Having tried these various methods and experienced some difficulty in determining the exact position of foreign bodies in the human eye, the author devised a simple instrument which in his opinion does the work in a far more efficient and satisfactory manner than has heretofore been possible.[2]

As is well known, the location of foreign bodies by means of the Roentgen rays is possible only when such bodies are either partially or completely opaque to the rays. If a photographic plate is placed in the path of the rays, the shadow of the opaque object is projected on the photographic plate, and its position is determined by means of the position of the body, as compared with the position of the shadow of recognized parts of the body by which it is surrounded.

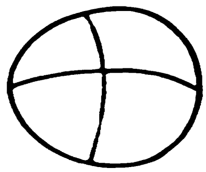


FIG. 175.—AUTHOR'S LOCALIZER.

FIG. 176.—AUTHOR'S LOCALIZER.

In an organ so delicate as the eye, sunk as it is far in the orbital tissue, considerable difficulty has been experienced in determining the exact position of the foreign body by a finder or localizer, opaque to the Roentgen rays, placed outside of the eye. In order to minimize this difficulty the author has devised a localizer which comes directly in contact with the anterior half of the eye, and its geometrical shadow, thrown on the photographic plate, aids in locating a foreign body in the orbit or eyeball. This is especially so since the outside rim of the localizer is formed of an opaque substance, so that, if care be taken, the position of the eye will be clearly determined by the geometrical shadow of the localizer. The apparent position of the foreign body will, of course, depend on its distance from the photographic plate, and

[1] "The Roentgen Rays in Medical Work," Walsh, 1899, p. 115.
[2] *Phila. Med. Jour.*, February, 1902.

FIG. 177.—AUTHOR'S LOCALIZER IN POSITION, SHOWING FOREIGN BODY. (Front View.)

it is absolutely necessary that the direction of the rays, and the position of the plate, be borne in mind when estimating the location of the body by means of the Roentgenograph.

The localizing device consists of an oval band of gold or silver, about 0.75 mm. in width, so shaped as to conform to the outline of the eye. It is provided with two gold strands crossing in front at right angles, thus dividing the instrument into quadrants. This form of localizer has recently been improved.

The new form of the localizer differs but slightly; there are two nearly concentric bands or circles with cross wires connected

FIG. 178.—AUTHOR'S LOCALIZER IN POSITION, SHOWING FOREIGN BODY. (Side View.)

thereto, leaving a clear space for the cornea. Generally, however, the author has obtained the best results with the form shown in Figs. 175 and 176.

The latest modification of this instrument consists in substituting for the outer band one of smaller diameter. This device accomplishes the same localization with less shadow. The foreign body must be very minute to be eclipsed by the shadow made by this localizer.

When in use the localizer is adjusted directly to the surface of the eye to be examined, a solution of cocain having been previously applied to the cornea and eyelids, thus permitting the instrument to remain in place long enough to make one or two Roentgenographs without inconvenience to the patient.

The localizer adjusts itself to the eyeball, but does not prevent the eye to which it is attached from rotating or following the other eye. In order to bring the crossed wires directly over the center of the cornea of the eye to be photographed, it is necessary to direct the other eye to a fixed point. The photographic plate being adjusted on the side of the temple nearer the injured eye, the Crookes' tube is then adjusted so that the Roentgen rays shall, as nearly as possible, fall perpendicularly on the surface of the photographic plate. If the foreign body lies within the shadow of the localizer, it must be in front of the equator of the eyeball; its distance behind the shadow of the instrument also determines its location, either in the posterior portion of the globe or orbit. A second occipito-frontal Roentgenograph at once identifies the quadrant in which the foreign body lies.

It will be noticed in the Roentgenograph shown herewith (Fig. 170) that some outlines of the localizer are sharper or clearer than others. In all cases the clearer outlines of the localizer indicate the position nearest the photographic plate. To a certain extent, therefore, the position of the foreign body can be judged by the sharpness of its shadow. Its absolute location may be verified by a second or control test. This test is made by placing a plate, not on the temporal side, but in front of the eye, and having the X rays pass through the head. This second or occipito-frontal Roentgenograph is not so clearly outlined in its details as the first or temporal Roentgenograph, but with a little experience one can recognize any foreign body seen in the first

test. The one defect in the method is that if the foreign body is very small and lies directly below the shadow of the localizer, it cannot be seen. In this case an additional temporal or occipito-frontal Roentgenograph must be taken with the source of the rays at a diverging angle, and no longer perpendicular, as in the first instance.

FIG. 179.—LOCALIZER, SHOWING FOREIGN BODY IN THE EYEBALL.

Since taking his first Roentgenograph some ten years ago, the author has succeeded in materially reducing the time of exposure. He thus eliminates an objectionable feature in the use of X-rays in ophthalmic work—namely, the danger of exciting conjunctivitis or dermatitis about the temple or the eyelids, and even of the inner tunics of the eye itself. In his ophthalmic work on living subjects the author obtains excellent temporal Roentgenographs by an exposure of from five to ten seconds, while the occipito-frontal Roentgenographs require about thirty seconds.

Regarding the technic of taking the radiographs the following report is given by Dr. G. E. Pfahler:[1]

"A. *Temporal Roentgenogram.*

"1. Cocainize the injured eye, place the localizer in position by fitting it carefully under the eyelids, resting upon the cornea.

"2. Place the patient upon the Roentgenographic table with the injured side of the head lying upon the plate. Immobilize the head by means of sand bags or by a weighted band thrown over the head.

"3. Fix the eye by having the patient look at an object in a horizontal plane, parallel with the level of the plate. A mirror is most useful for this purpose.

[1] Director of the Roentgen-Ray Laboratory, Medico-Chirurgical Hospital.

fragment be of metallic nature, removal by the electro-magnet may be practicable; if the body quivers on the approach of the magnet the indications are favorable for removal by this means. The needle may be introduced through the original wound, or a new incision made through the sclerotic close to the location of the foreign body. The position of the patient's head must be carefully considered if the foreign body moves with motions of the head, and it is sometimes necessary to perform the operation with the patient seated. Should the foreign body be located in the lens, this structure should be immediately removed, as in cataract operation. If the fragment is located directly behind the lens, its removal may be effected at the same time, or immediately after the removal of the lens. If the foreign body can only be removed by sacrificing the lens, this sacrifice should be made, since a foreign body in the vitreous rarely fails to set up hyalitis or glaucoma; it may also produce retinal detachment or give rise to sympathetic ophthalmia, as already mentioned.

FIG. 180.—LOCALIZER, SHOWING BIRD SHOT IN THE EYE AND SURROUNDING TISSUES.

If a fragment of iron or steel cannot be seen on account of obscuration of the media, it may be of advantage to employ a sideroscope, which essentially consists of a magnetic needle which is highly sensitive, and which becomes deflected when an eye containing the metal is brought close to it. Sideroscopes have been devised by Hirschberg and Asmus.

Magnets for the extraction of foreign bodies from the interior of the eye, while used in a very crude manner for some time, were not brought before the profession until 1874 when MacKeown extracted a fragment of iron from the vitreous by means

of a permanent magnet having a tapering point. In 1880 magnetized steel rods were used by Gruening. In 1881 the Hirschberg magnet was devised, and in 1885 the giant one of Haab.

The Hirschberg Magnet.—This consists of a coil of copper wire wound around a rod of soft iron. The ends of the wire are connected with a powerful galvanic current. The extremities of the iron rod, which protrude slightly beyond the spiral of copper wire, are slightly bent and terminate in a blunt point for introduction into the eye, which can be inserted either through the original wound itself, provided the aperture is still large enough and recent, or an incision can be made in order to gain access to the supposed location of the foreign body. The introduction of such an instrument within the eye, and especially within the vitreous, is fraught with disadvantages, which have been largely overcome by the giant magnets, especially that of Haab.

The Haab Giant Electro-magnet.—The patient is seated on a revolving chair, as both the patient and his head are more easily

FIG. 181.—THE VICTOR ELECTRO-MAGNET.

moved than the instrument itself, which weighs 38 kilogrammes. The patient is directed to look toward the pole of the magnet. The principle of the operation of the instrument consists of opening and closing the current until the foreign body is dislodged. Pain and bulging of the iris signify that the foreign body has

been attracted through the vitreous, around the lens, and against the posterior surface of the iris. If the application of the central part of the cornea toward the pole of the magnet does not disclose the presence of a foreign body a greater circumference of the cornea is brought in approximation, carefully avoiding the region of the ciliary body. It requires great skill to attract the foreign body from behind the iris into the anterior chamber, but if brought so far a corneal incision will usually permit of its removal. Haab emphasizes that the magnetism of the instrument should be concentrated at a point from which the foreign body is to be drawn, in order that the foreign body will be propelled along the route which it will have to follow from the vitreous. If the foreign body is located within the eye in a portion other than the vitreous, it should be first loosened by intermittent attractions, which Haab has now facilitated by adding a switch to the lower part of his instrument controlled by the foot. If the foreign body is large it is obviously attracted with greater power, in which case it is better to withdraw the patient farther away from the instrument. The eye should first be anesthetized and the pupil dilated in order to facilitate the drawing of the foreign body into the anterior chamber. Whatever comes in proximity to the eye, excepting the pole of the instrument, should be nonmagnetic. Sweet, Johnson, Lippincott, and others have devised modifications of the Haab instrument, which are smaller but less powerful.

If infection has already commenced, cold compresses should be applied to the eye and leeches to the temple, with the view of allaying the attendant inflammation. The pupil should also be dilated to its full extent, and the eye placed at rest by the local administration of atropin, and if a suppurative iritis or iridocyclitis supervenes, it may be necessary to administer mercury, a most valuable procedure. These measures are, of course, to be resorted to before the operation has been performed.

CHAPTER XIX

DISEASES OF THE ORBIT

General Considerations.—In order clearly to understand the pathological conditions occurring within the orbit, it is necessary briefly to reconsider its anatomical peculiarities. It is a bony cavity having the shape of a quadrilateral pyramid, its apex communicating directly with the cavity of the skull. It is surrounded by the nasal fossæ, the ethmoidal sinus, the sphenoidal sinus, the frontal sinus, and the antrum of Highmore. Contained within the orbit are the eyeball, ocular muscles, optic nerve, blood-vessels, nerves, and lacrymal gland, the interspaces of which are filled with fat and fascia.

The fascia of the orbit is of considerable importance on account of its numerous folds. One portion of it lines the orbit as the periosteum of its bony walls, while another is reflected anteriorly from the margin of the orbit to both tarsi, constituting the *sæptum orbitale*. Another layer surrounds the globe from the cornea to the posterior portion of the ball, forming an articular socket with the contiguous surface of the sclera, which is known as the capsule of Tenon. It is lined with endothelium and communicates directly with the supravaginal space of the external sheath of the optic nerve. The fascia is also prolonged over the ocular muscles as they pierce this capsule.

The blood-vessels of the orbit deserve attention, as they may be the starting-point of some of its diseases. The ophthalmic artery and its branches derived from the internal carotid artery supply the orbit with arterial blood. The venous blood is collected by corresponding veins and emptied into the ophthalmic vein, which joins the cavernous sinus.

The third, fourth, fifth, and sixth cranial nerves are found within the orbit in addition to the optic nerve. The third, fourth, and sixth are motor nerves, while the ophthalmic and superior

maxillary branches of the fifth constitute the sensory nerves. Along the course of the ophthalmic branch of the fifth nerve is the *lenticular* or *ciliary ganglion*, situated in the posterior portion of the orbit between the optic nerve and the external rectus muscle, and usually to the outer side of the ophthalmic artery. It receives motor fibers from the third nerve and sympathetic filaments from the carotid plexus. Its branches of distribution are the short ciliary nerves.

There are no lymphatic glands or lymph vessels within the orbit.

All affections of the orbit are characterized either by an increase or decrease in the size of its contents or walls. With an

Fig. 182.—Asymmetry of Face—Right Eye Four Lines Above Horizontal Plane. Orthophoria.

increase in the size of the orbital contents or an encroachment upon the cavity by enlargement of its walls, the eyeball protrudes, *exophthalmos*. When the opposite conditions supervene the eyeball recedes into the orbit, and is known as *enophthalmos*.

Symptoms.—In all forms of orbital disease there are certain common symptoms. Two of the most frequent are exophthalmos and immobility of the eyeball. This immobility is differentiated from that due to external ophthalmoplegia by the absence

of ptosis. Owing to the occurrence of affections which encroach upon the orbital cavity either from within or without, exophthalmos is very common. Diplopia is present if vision is retained; occasionally the range of ocular movements is increased. Fluctuation sometimes occurs, especially if an abscess is present. Visual disturbances may occur as the result of changes in the eye-grounds. Pain is rather frequent and tenderness may be elicited if inflammation is present. There is always more or less congestion and inflammation of the conjunctiva.

CONGENITAL MALFORMATIONS

In rare instances the orbits fuse during fetal life, so that only one orbit and one eye are present at birth, situated at the root of the nose. Such a condition is termed *cyclopia*, and is attended by other abnormalities of the head and brain. More frequently the eyeball is the seat of congenital malformations, thereby altering the contents of the orbit and interfering greatly with its subsequent development. A congenital absence of the eye, or ***anophthalmos***, is usually bilateral, and is believed to result from a failure of development of the primary or secondary optic vesicle. It is often incomplete, and the eyeball is represented by a cyst of the lower lid within which may be found a rudimentary globe. A condition somewhat allied to this is the marked diminution of all the diameters of a completely developed eye, which is designated *microphthalmos*. The opposite condition of overdevelopment is termed *macrophthalmos*, and is attended by glaucoma and keratoglobus. The affection known as buphthalmos may be mentioned as a good example. The effect such congenital conditions have upon the development of the globe is obvious, and it must be remembered that a somewhat analogous condition is produced by enucleation of an eyeball in very young children, the resulting imperfect development of the corresponding orbit producing marked facial asymmetry.

INFLAMMATIONS OF THE ORBIT

Periostitis of the orbit is sometimes observed, and it may be acute or chronic, localized or diffused. It may occur alone or associated with orbital cellulitis. As in periostitis elsewhere,

it may terminate in thickening, suppuration, or caries and necrosis.

Prominent among its causes may be mentioned injuries to the orbit, received accidentally or through careless surgery, syphilis, tuberculosis, rheumatism, and extension from adjacent structures, such as suppurative processes in the accessory nasal sinuses. It has often occurred in association with carious teeth and after extraction.

The **symptoms** vary considerably, according to the nature and course of the affection. In the most common form which attacks the orbital margin, there is present pain, tenderness upon pressure, hard immovable swelling, exophthalmos, and congestion of the conjunctiva and lids.

The exudate thus formed may be retained, absorbed, or thrown off. If retained, there is periosteal thickening; if absorbed, there is restitution to normal; if thrown off, there is suppuration, caries, and subsequent fistula formation. In the diffuse variety of periostitis all these symptoms are intensified, and, in addition, fever, headache, anorexia, constipation, delirium, and stupor are liable to supervene at any time. The pus may be discharged anteriorly or posteriorly, the latter being always followed by meningitis or cerebral abscess. Chronic periostitis is nearly always of syphilitic origin, and is attended by deep-seated nocturnal pains, thickening, and exophthalmos. Gumma of the periosteum may occur, in which case the swelling is distinctly localized.

Treatment.—In all cases the iodids, salicylates, and mercury should be administered freely. Locally, in acute cases hot compresses should be applied frequently, and early incision is indicated in order to relieve the tension of this very dense structure.

The **prognosis** in localized types is very favorable under prompt treatment, but its possible terminations should always be borne in mind. Chronic periostitis may last indefinitely. Syphilitic cases present the most favorable outlook.

Caries and Necrosis.—The altered nutrition of the bones of the orbit induced by the periostitis leads to death of the bone in particles. In the discharge of these particles suppuration is an accompaniment. A fistula is always present, the opening of which is surrounded by granulations. This fistula persists until

the discharge of the carious particles is complete. The condition is most common in children as the result of syphilis and tuberculosis. Necrosis is observed with greater frequency in adults. It usually selects the margin of the orbit. Treacher Collins, Walker, and Parsons have observed cases of necrosis of the orbital plate of the frontal bone.

Treatment.—Internally, cod-liver oil, hypophosphites, sirup of the iodid of iron, and similar tonics combined with good food, fresh air, abundance of sunshine, etc., are of great value. Locally, antiseptic solutions should be used to cleanse the fistulous tract, and the carious material should be removed as soon as it has been cast off.

Drainage should be employed, and in persistent cases curettement of the bone may be necessary.

Cellulitis, or inflammation of the cellular tissue of the orbit, is an acute affection which almost invariably terminates in suppuration. It arises from injury, local infection from surgical operations, and general infection through the blood, as in pyemia, septicemia, erysipelas, etc., extension of inflammation from adjacent structures, such as suppurative processes in the accessory nasal sinuses. It has often occurred in association with carious teeth and after extraction. It occasionally occurs without any assignable cause.

Bacteriology.—This obviously depends upon the bacteriological conditions of the adjacent structures. Even when associated with empyema of the accessory sinuses of the nose, orbital infections at one time were considered as due to metastatic involvement. As a result of a better knowledge of these structures, we now know that metastasis is more rarely the cause, the latter usually being an extension through the venous circulation, or by a progressive necrosis of the separating bony structures. As the result of natural drainage, which does not exist in the case of the orbit, the contents of empyemata may escape through the nose, while the orbital lesion remains unrelieved. An exception to this is in the case of very young children in whom the accessory sinuses are as yet poorly developed. According to Fuchs, the lacrymal sac, on account of its intimate proximity to the sinuses, may give rise to orbital involvement. Some of the chief organisms that have been found are pneumococci, strepto-

cocci, the two combined, staphylococci, influenza bacilli, and in the case of fetid pus, anaërobic saprophytes.

Symptoms.—The affection is manifested by chills, fever, anorexia, and other constitutional phenomena incident to suppuration anywhere in the body. Locally, the eye is protruded, the lids are swollen, and the conjunctiva chemosed. There is violent pain in the orbit and side of the head, which is increased upon pressure and upon any attempt to move the eye. Pus usually makes its appearance at the end of a week, and may discharge spontaneously into the fornix through the lids. Fluctuation may be obtained, particularly at the inner portion of the supra-orbital ridge. Vision is unaltered unless there is a coincident optic neuritis, a not infrequent complication. Thrombosis of the retinal vessels, panophthalmitis, and extension to the brain may be mentioned as occasional complications.

Diagnosis.—Orbital cellulitis is usually very easily recognized, but occasionally it is simulated in part by thrombosis of the cavernous sinus. In this latter affection there is present exophthalmos, edema of the lids, chemosis of the conjunctiva, and lessened corneal sensations, together with rigors, high fever, nausea, vomiting, constipation, etc. The distinction between the two conditions may be made by the third-nerve palsy, congestion of the papilla, and the presence of infective inflammation in one of the cavities of the skull in thrombosis.

Treatment.—Constitutional treatment should be maintained from the beginning of the affection. Purgation with the administration of small doses of mercury seems to have a decided antiphlogistic effect. Iron, quinin, strychnin, alcohol, etc., should also be administered. Morphin may be required to relieve the pain. Locally, hot fomentations of poppy heads are of great benefit, together with leeching of the temple. Early and deep, single or multiple incisions either through the skin of the lids or conjunctiva are indicated upon the slightest suspicion of suppuration. Subsequent antiseptic irrigation materially aids the progress toward cure.

Prognosis.—The prognosis is favorable in mild cases, and less favorable as the severity of the affection increases. Blindness may follow from optic neuritis, retinal hemorrhage, or corneal suppuration. The eyeball may be lost through panophthalmitis;

or death may be induced by cerebral involvement. It is always a serious affection.

Tenonitis.—Inflammation of Tenon's capsule is a very rare orbital condition, and when present it is serous in character. Purulent cases have been reported usually due to endogenous infection.

The affection may follow tenotomy or enucleation. Rheumatism, exposure to cold, and other constitutional disturbances may induce it. Occasionally it arises without any apparent cause.

It is manifested by exophthalmos, limitation of ocular movements, pain in the eye, particularly on motion, chemosis of the conjunctiva, and swelling of the upper lid. The duration is about three weeks. The diagnosis is made by exclusion.

Panophthalmitis.—This is an inflammation of the entire eyeball. This affection is really an acute purulent uveitis, but is considered in this connection to complete the inflammations of the orbital contents.

Etiology.—It always arises from infection of the eyeball either accidentally or as the result of operations. The entrance of foreign bodies is a very frequent cause. Perforation of infected corneal ulcers is also an important etiologic factor. The infection may take place through the blood, as in the cases occurring in the course of septicemia, pyemia, cerebrospinal meningitis, and other infectious fevers. In the case of perforating wounds, panophthalmitis is usually due to an extension into the vitreous, from where it may soon involve the other structures. The fertility of the vitreous as a culture medium in the living subject, in contradistinction to sterilized vitreous humors outside of the body (Herrnheiser), is striking.

Symptoms.—Owing to the early stages of this affection being localized in the uveal tract, the symptoms of purulent iritis, cyclitis, and choroiditis are particularly prominent. The lids are swollen and the conjunctiva is congested and chemosed. Pain of varying intensity is present. Intra-ocular tension is greatly increased. There is rapid failure of vision, owing to the cloudiness of the cornea and the purulent exudate in the aqueous and vitreous, and it becomes impossible to view the fundus. All the structures of the eyeball become rapidly infiltrated with pus, ending in its total destruction.

The inflammatory process extends to Tenon's capsule and cellular tissue of the orbit, producing exophthalmos, and greatly limiting the ocular movements. Rupture of the eyeball occurs in most cases, after which there is a subsidence of the symptoms. Later shrinking takes place, constituting the condition known as *phthisis bulbi.*

Treatment.—The administration of tonics should never be neglected in this condition, as they aid in resisting any extension of the inflammatory process. Mercury is also of value for its antiphlogistic effect, particularly when combined with saline purgatives. The pain is sometimes very intense and requires hypodermic injections of morphin for its relief. Locally, the application of hot moist compresses is also of value and should not be forgotten. Enucleation of the eye is always required sooner or later. Some authorities do not advise removal of the eye until the acute inflammation has subsided, fearing lest purulent meningitis should supervene. Deep scleral incisions are substituted for enucleation in order to evacuate the pus. Evisceration is also employed.

Enucleation.—The operation of removal of the eyeball is not only employed in panophthalmitis, but also in eyes blind as the result of traumatism, iridocyclitis, and glaucoma. Malignant tumors, sympathetic ophthalmia, and the presence of foreign bodies in the eye, particularly in the ciliary region, are additional indications.

Vienna Method.—General anesthesia is always to be induced for these operations unless especially contraindicated. The eye speculum is introduced and the eye is irrigated by means of some antiseptic solution. The conjunctiva is grasped close to the cornea with the underlying tendon of the internal rectus muscle and divided around the entire corneal margin. A pair of long, straight, thin, blunt-pointed scissors are then introduced with one blade beneath the internal rectus muscle, which is divided close to its scleral insertion, leaving enough of its distal attachment for holding the eye by means of forceps. The scissors is then swept around the globe, severing each muscle with which it comes in contact in a similar manner. All other attachments to the globe are likewise severed by the scissors, care being taken to save as much of the orbital tissue as possible. A heavy

pair of curved scissors are then passed along the eyeball, which may be forced out and the optic nerve divided, keeping the heel of the scissors close to the globe, so as to avoid "buttonholing" it. Rupture of the globe may occur during the operation, and render it more difficult than under other circumstances. In such cases the tunics of the eyeball should be grasped by fixation forceps and dissected from their attachments by means of scissors. In staphylomatous eyes it may be necessary to employ a strabismus hook to bring the muscles into view, but ordinarily this procedure may be dispensed with to advantage.

After the eyeball has been removed hemorrhage should be controlled by firm but gentle pressure, a sterilized sponge being used over the eyelids, pressing them inward until the bleeding stops.

Bonnet's Method.—The speculum is introduced. The conjunctiva and subjacent fascia are divided with scissors as close as possible around the corneal margin (circumcision of the cornea). A strabismus hook now raises the tendons of the ocular muscles and severs them one at a time, beginning with the superior rectus. After the muscles are severed the speculum is inserted somewhat more deeply, causing the eyeball to protrude somewhat, the object being to dislocate it as far as feasible in order to facilitate the subsequent division of the optic nerve. A pair of long curved scissors (enucleation scissors) are now inserted between the eyeball and the [illegible] and carefully introduced posteriorly by following the [illegible] of the eyeball until they reach the optic nerve. The blades of the scissors are now opened and the nerve is severed close to the eyeball. The oblique muscles are then severed, together with [illegible] other structures [illegible] either [illegible]

[illegible] which are [illegible] muscular attachments [illegible]

Implantation [illegible] — [illegible] globe is removed [illegible] the tissues [illegible] the tissues [illegible] these sutures [illegible] and

14 mm. in diameter, and are preferable to the glass balls formerly used, in that they are unbreakable and are unaffected by the tissue fluids. The recent removal of a number of glass balls from the eyes of patients has demonstrated that the surface

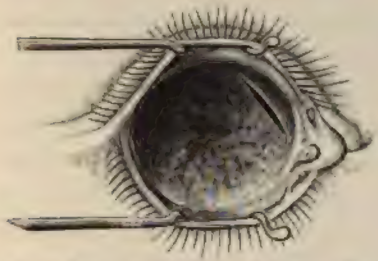


FIG. 183.—ORBITAL TISSUES BEFORE INSERTION OF GOLD BALL.

FIG. 184.—INSERTION OF GOLD BALL IN ORBITAL TISSUES.

polish is destroyed and the glass eroded by the action of the tissues and their fluids within a comparatively short period (two years). The ball is held in position by a metallic conformer, which is placed directly over it and inside of the lids. An antiseptic dusting powder is freely dusted over the line of sutures. This is retained for a period of two or three days. The sutures are removed on the third or fourth day.

The advantages of this operation are as follows: More of the orbital tissues are retained than by any other similar procedures, and by their union over a gold globe a movable stump is formed. The gold ball is aseptic and never breaks. It never escapes unless the tissues overlying it are prevented from cicatrizing due to retraction of the underlying structures. An artificial eye may be worn with decided comfort after such an operation, and may be moved synchronously with the fellow eye. This may be further facilitated by glass eyes having a cup-shaped depression on their posterior surface, being held in contact with the gold ball by suction.[1]

Implantation after Remote Enucleation.—In orbits from which the globes have been removed for a more or less considerable period of time the technic of the operation is slightly modified. In operating upon such an orbit, right side, after separating the

[1] This new eye has been made for the author by Wall & Ochs, of Philadelphia, and is a great improvement over the artificial eye in general use.

lids with a speculum, the conjunctiva is grasped up and in, above the inner canthus in order to draw out the tissues. A Beer's knife or curved keratome is passed through the tissues obliquely and well down into the orbit, making an opening large enough to allow the ball to be pushed in behind the conjunctiva and other orbital tissues (Fig. 183). The opening is so placed that on completion of the operation the wound edges will be to one side of the gold ball, and consequently will not be subjected to any pressure. The gold ball is thus prevented from breaking through the center of the conjunctiva. Curved scissors are introduced into the opening and are used to separate the tissues from the fibrous bands which have formed in the orbit, thus making a large pouch or *cul-de-sac* into which the globe can be inserted. In performing the operation on the left orbit, the incision is made up and out above the external rectus muscle, and the dissection carried out as already described. The gold ball (Fig. 188[11]) may be introduced by a special instrument (Fig. 188[7]) or by the fingers, and is aided in its lodgment by the scoop (Fig. 188[6]). The incision is closed by two sutures, and the ball is retained in place by a metal shell modeled after an artificial eye and termed a "conformer" (Fig. 188[12]). The after-treatment is the same as in the preceding operation.

Mules' Operation.—The operation as performed by the author is as follows:

First Stage.—After general anesthesia, the face around the eye, including the eyebrow and eyelids, is carefully cleansed with neutral soap and warm water, followed by a bathing of a solution of bichlorid (1-2,000). The face is covered by a veil of gauze having an opening over the eye to be operated upon.

Second Stage.—An eye speculum is introduced between the lids, the conjunctiva is separated around the corneal margin with straight scissors and dissected back as far as the equator of the eyeball, freeing the conjunctiva, Tenon's capsule, and all intervening tissue. A Beer's or Sichel's knife is passed through the upper half of the cornea, as in the old flap operation for the extraction of cataract. This flap is then grasped with forceps, and the lower half of the cornea is removed with curved scissors.

Third Stage.—The contents of the globe, vitreous, retina, and

choroid are removed by inserting a spoon-shaped instrument between the ciliary body and sclera, rotating the scoop around the scleral cavity several times, and with the last turn making a sweep across the head of the optic nerve, and finally withdrawing the scoop with the scleral contents. In this way the author has, on many occasions, completely eviscerated the contents of the globe unbroken. When this is not possible the cavity may be cleansed with gauze sponges wrapped around the tips of the forceps. To prevent hemorrhage from the central artery the cavity is packed with iodoform gauze, which is allowed to remain a few minutes. From the corneal opening, both above and below, a small triangular portion of the sclera is cut out in order that the coaptation of the scleral edges over the gold ball may be more nicely adjusted. If this is not done puckering edges of the sclera may project through the conjunctiva, slightly interfering with the adjustment of the artificial eye later on.

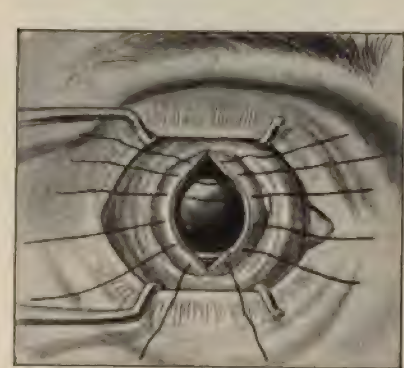


FIG. 185.—MULES' OPERATION; GOLD BALL INSERTED IN SCLERAL CAVITY; SCLERAL SUTURES IN SITU.

Fourth Stage.—All muscles are snipped close to the eyeball, after which the eyeball stands out relieved from all attachments excepting the optic nerve, the blood-vessels accompanying it, and the ciliary vessels.

Fifth Stage.—A 13 or 14 mm. gold ball, carefully sterilized, is introduced into the scleral cavity by a specially devised instrument. The edges of the scleral opening are then united vertically by means of black dialyzed silk sutures, two lines apart. It is sometimes with great difficulty that the needle is passed through the edges of the sclera on account of the density or toughness of the tissues. If, however, an eyelet forceps is used the passing of the needle becomes easy. The conjunctival opening is closed by 8 or 10 stitches placed at right angles to the vertical scleral line. In stitching the conjunctiva it is very important to pass the needle also through the capsule of Tenon, because in

so doing the heads of the four recti muscles are again brought forward and subsequently reattach themselves to the eyeball so that little or no rotation is lost. In many of his earlier operations the author found that, notwithstanding the exercising of all care and perfection of technic, the central stitches of the scleral wound would give way and the gold ball would be exposed and eventually expressed. Upon seeking the cause I came to the conclusion that owing to the great irritation caused by the separation of tissue around them, the attached muscles became contracted and in this way pulled upon the stitches in the sclera with great force, so that the weakest spot would be at the center of the scleral wound, which would, occasionally, give way. After all the muscles were tenotomized there was no further trouble of this character. The orbital cavity is always thoroughly irrigated with 1–2,000 bichlorid-of-mercury solution after the completion of the operation.

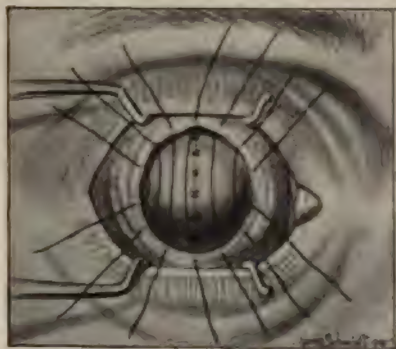


Fig. 186.—Mules' Operation; Sclera United; Conjunctival Sutures in Situ.

A glass or gold-plated "conformer" is then inserted between the eyelids. The "conformer" is shaped to the contour of the globe and acts like a splint and support to the conjunctiva and scleral wounds. Over the conformer the orbital cavity is filled with an antiseptic powder, such as xeroform or bismuth formic iodid (Mulford), the lids are closed and covered with a generous amount of sterile vaselin.

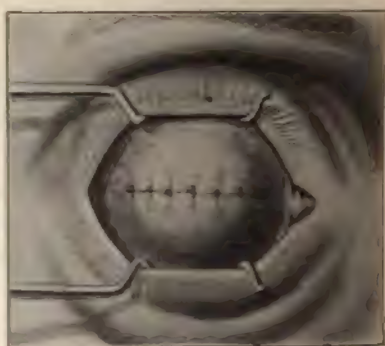


Fig. 187.—Mules' Operation; Conjunctiva United.

Sixth Stage.—A bandage producing a fair amount of pressure is adjusted over both eyes, and it is not removed for forty-eight hours. Sometimes, if there be excessive reaction, indicated by great pain, the bandage is slit vertically over the ears with a pair of scissors to relieve pressure, but the bandage is not removed. However, this happens but rarely. In cases of extreme pain I have resorted to an opiate for relief. My object in using this bandage is to keep the eyelids closed, preventing any movement of the eyeballs. Healing then goes on very rapidly. The bandages are removed at the end of forty-eight hours, and both eyes are bathed with warm sterile water. The operated eye has then an additional bath of water, as hot as can be borne, by the hand of the dresser. The orbital cavity is thoroughly irrigated by hot boric-acid and camphor-water lotion. The conformer is not as yet taken out. Both eyes are again bandaged, but instead of a dry antiseptic dressing we substitute an antiphlogistic lotion, consisting of the following formula:

℞ Liquoris plumbi subacetatis diluti	. fl ʒij;	8.0
Tincturæ opii, Tincturæ belladonnæ,	} . . . . . . āā fl ʒjss;	6.0
Tincturæ arnicæ	. . . . fl ℥j;	30.0
Aquæ camphoræ, Aquæ destillatæ,	} . . āā q. s. ad. fl ℥iv;	120.0

Misce.

This lotion is applied constantly to the operated eye in the form of iced compresses. The lotion should be placed in an iced bowl and the compresses kept wet by dropping the cold lotion on them throughout the day and night. By such methods excessive swelling is prevented. The conformer and the conjunctival stitches are removed on the third or fourth day. This is important, as I found stitch abscesses would develop if they were allowed to remain longer. The scleral sutures remain permanently. There is always some swelling of the lids and at times there is considerable edema of the conjunctiva, which, however, should cause no anxiety. The artificial eye is not usually adjusted until four or six weeks have elapsed.

In a large number of cases (425) extending over fifteen years,

the author has not had one case of sympathetic ophthalmia follow this operation. In one case, where sympathetic ophthalmia had shown itself in the fellow eye in the form of iridocyclitis, he performed a Mules' operation instead of an enucleation, and had the satisfaction of seeing the inflammatory process rapidly clear away in the sympathizing eye. The removal of the contents of the

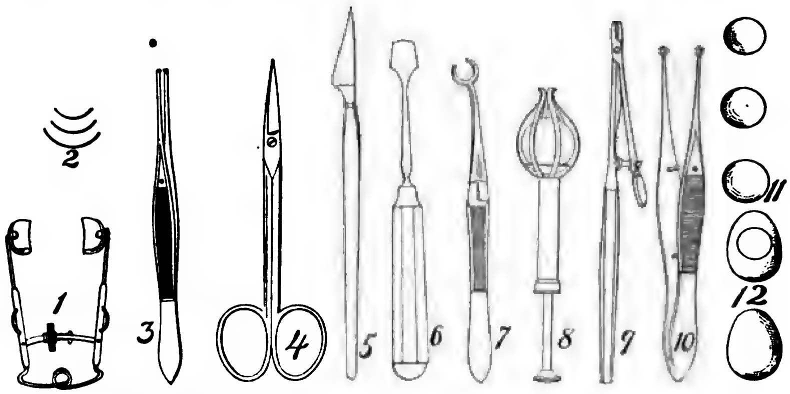


FIG. 188.—INSTRUMENTS FOR MULES' OPERATION.

1. Terson's speculum. 2. Half curved needles. 3. Fixation forceps. 4. Straight scissors. 5. Sichel knife. 6. Carter's evisceration scoop. Instruments for introducing gold ball. 7. Fox's. 8. Carter's. 9. Stevens' needle holder. 10. Eyelet forceps. 11. Gold balls. 12. Metallic conformers; two models.

primarily affected eye seemed to remove the cause of the irritation. This patient is still under observation, and no trouble has been experienced in five years.

Six rules laid down by Mr. Mules why this operation should be performed instead of the enucleation of the eyeball are:

(1) Retention of the framework of the eye. (2) A firm, round globe forming perfect support for artificial eye. (3) Perfect harmony of muscular movement retained. (4) Fitted with selected eye defies detection. (5) No qualms as to personal appearance. (6) No interference with growth of orbit.

The formation of an artificial vitreous by means of paraffin has sometimes proven a commendable procedure. Evisceration was devised as a substitute for enucleation. Dr. James M. Crawford, Atlanta, Ga., is an ardent advocate of abscission, with which he has had considerable experience.

Skin-Grafting.—If it possibly can be avoided, skin itself should never be implanted in the orbit on account of desquamation of

the epithelial layers, which causes an excessive amount of secretion, resulting in a deposition on the artificial eye, repulsive-looking, and disagreeable to the patient. The mucous membrane of the mouth is far preferable for the purpose.

Prognosis of Panophthalmitis.—The prognosis of panophthalmitis is always unfavorable, as the inflammation destroys all the structures, and shrinking of the globe is a constant termination, rendering the eye completely blind and useless. It bears no relation to sympathetic ophthalmia.

INJURIES OF THE ORBIT

Under this heading may be included lacerations and contusions of the soft parts, fractures of the bony walls, and foreign bodies. Traumatism of the soft parts may result in hemorrhage or contusion of the supra-orbital nerve. In hemorrhage the extravasated blood may give rise to exophthalmos or it may induce optic atrophy by pressure on the nerve. Involvement of the supra-orbital nerve has been said to have induced amaurosis reflexly. Inflammatory reaction after wounds of the soft structures within the orbit may be intense, and suppuration and orbital abscess may develop. In fractures of the bony walls there is always injury to the adjacent soft structures, and injury to the nerves is not uncommon. The optic nerve may be directly or indirectly injured. Emphysema is a rather common accompaniment. Foreign bodies frequently enter the soft tissues of the orbit without involving the eye, and while there is always a possibility of the foreign substance penetrating the orbital wall and entering the brain, it is by no means rare to find very large substances lying encapsulated in the orbit without giving rise to any serious symptoms, and often without attracting attention.

Treatment.—All fragments of bone and foreign bodies should be carefully removed. Thorough cleansing is always necessary, and measures should be taken to prevent inflammation and its sequels. Incision and removal of the clot may be called for in excessive hemorrhage, or suturing of the detached ends of muscles cut by the traumatism. Antiseptic lotions should be freely applied at short intervals.

ORBITAL TUMORS

Pulsating Exophthalmos.—Under ordinary circumstances exophthalmos is not attended by pulsation, but in arteriovenous aneurysm due to rupture of the internal carotid into the cavernous sinus following traumatism the eyeball and surrounding parts may protrude and pulsate. The patient complains of pain and peculiar noises in the head. Ptosis is also present. A distinct bruit may be heard over the eye and forehead, and the retina, conjunctiva, and eyelids are markedly congested. The cornea may be slightly cloudy and less sensitive than normal. The pupil is dilated and sluggish. Compression of the common carotid artery has been highly recommended and usually causes a disappearance of the pulsation and bruit. The literature on pulsating exophthalmos has been systematically brought up to July, 1907, in the valuable monograph of De Schweinitz and Holloway.

According to Fick, it may follow an injury either direct, as a puncture through the orbit or a penetrating shot; or indirect, as a fracture at the base of the brain; or it may be due to arteriosclerosis or syphilis of the arterial walls which yield to some slight rise of blood-pressure, such as accompanies coughing.

Treatment.—The object of the treatment in these cases is to bring about thrombosis of the cavernous sinus. This may be greatly aided by rest in bed and restricted diet, reducing the liquids to a minimum. This procedure serves to lessen arterial pressure. Operative treatment consisting in compression or ligation, however, will be required. Electrolysis has been employed with gratifying results.

Prognosis.—It is impossible to forecast the termination of this condition with any degree of certainty. The prognosis as to life is good, but that as to vision should be guarded. The exposure of the protruding eyeball nearly always results in some corneal complication. Vision may be greatly impaired by the anemic condition of the retina or by neuroretinitis. The occurrence of repeated hemorrhages may threaten life. In the most favorable cases thrombosis of the cavernous sinus occurs, blocking up the wound in the arterial wall. About 7 per cent of cases recover without treatment.

Thrombosis of the Cavernous Sinus.—To appreciate this condition it will be necessary for the student to thoroughly comprehend the anatomy of the structures involved, and especially of the various venous channels which communicate with the sinus.

Symptoms.—The occurrence of this condition is manifested by the following symptoms referable to the eye: proptosis, edema of the eyelids, chemosis of the conjunctiva, haziness of the cornea with lessened sensation, partial or complete ocular paralysis, and sometimes inflammation of the optic nerve. Dilatation of the retinal veins may occur. According to Uhthoff, pathological alterations in the eye-ground occur in about 20 per cent of cases, other than those due to otitic or traumatic cause. It resembles orbital cellulitis (*q. v.*) in many respects. This condition may be a termination of a pulsating exophthalmos or it may be infectious in origin.

In cases following pulsating exophthalmos no treatment is necessary; but in septic cases antiseptic and constitutional measures are indicated, as a fatal termination is the rule.

Simple Exophthalmos.—Protrusion of the eyeball without any pulsation. This symptom is common to all affections of the orbit, and particularly tumors. The orbital inflammations that may induce this condition have been considered in the beginning of this chapter. The association of exophthalmos with ocular paralysis and Graves' disease has also been described elsewhere. The remaining conditions that may induce exophthalmos are tumors of the eye, tumors of the adjacent orbital tissue, and disease of the adjacent sinuses. The ocular tumors include glioma, sarcoma, and epithelioma. The tumors affecting the orbital tissues consist largely of gummata, sarcomata, dermoid cysts, and vascular growths. The adjacent sinuses, the frontal, ethmoid, sphenoid, and the antrum of Highmore may be the seat of osteoma or osteosarcoma, or they may be attacked by chronic inflammatory conditions in which a mucocele is formed in the orbit. Tumors of the brain, lacrymal gland, and optic nerve may also encroach upon the orbit and induce exophthalmos.

Orbital tumors, in addition to exophthalmos, are attended by a change in the direction of the eyeball, according to the size and location of the growth. There is also impairment of the motility of the eye, depending upon the location and pressure exerted by

the enlargement. Vision is interfered with only when the nerve is pressed upon, inducing optic neuritis and subsequent atrophy. These tumors may be considered as benign and malignant; the former grow slowly and give very few symptoms, while the latter are particularly rapid in growth and occasion great pain. Among the benign tumors may be mentioned cysts, aneurysm, angioma, pulsating exophthalmos, distention of adjacent sinuses, etc. The malignant tumors are carcinoma and sarcoma.

The cellular tissue of the orbit is occasionally the seat of gummata, sarcomata, cysts, and vascular growths.

Gumma in this region is most often encountered in the upper and inner portion of the orbit and is unilateral. The bony wall is

FIG. 189.—LARGE NÆVI OF THE FACE INVOLVING ORBIT. (Author's case.)

coincidently involved. The duration is long, and the affection responds very slowly to treatment, which should be pushed from the start.

Sarcoma of the orbital cellular tissue has been described, but is extremely rare. Its growth is rapid and is attended by great pain. The treatment consists in evisceration or exenteration of the entire orbital contents. The X-ray treatment is now followed, but statistics as to results are meager. A case of this character recently came under the author's observation in which the X-ray treatment was of very great service. The patient presented herself to him March 5, 1903, complaining of the enlargement of

the left naso-orbital region of six weeks' duration. Proptosis was present to a slight degree. Tension was slight. Very little pain was experienced. Vision was $\frac{6}{6}$ in both eyes; the fields were not contracted, but there was diplopia when an attempt was made to perform near work. The diagnosis of malignant growth, probably sarcoma, was made. An exploratory incision was made April 17, 1903, by Dr. Gleason to confirm the diagnosis. Microscopic examination of a section of tissue taken from the growth by Dr. Harold G. Goldberg revealed the presence of sarcoma cells of the spindle-cell variety. The ethmoid cells were opened, but very little pus or necrosed bone was encountered. The eye continued to protrude very markedly, and the general health began to fail. An unfavorable prognosis was given, and as a last resort the X-ray was tried by Dr. G. E. Pfahler, Medico-Chirurgical Hospital. For the first month twenty-eight applications were made. For the next two weeks three applications were given each week; this was reduced to two applications for one week, and then once every week until the present writing. The improvement was marked, and was due entirely to the X-ray treatment.

Cysts of the orbit include dermoid and echinococcus cysts. They are manifested by fluctuating tumors in the orbit, accompanied by exophthalmos, slight impairment of ocular motion, and slight pain. The diagnosis rests upon the examination of the cyst contents subsequent to removal. The echinococcus cyst, however, is not congenital; is of more rapid growth and is accompanied by more pain than a dermoid cyst. The characteristics of these cysts differ in no wise from the same cysts elsewhere in the body. Extirpation of the cysts is the treatment indicated.

The only case of echinococcus cyst which the author has had the opportunity of seeing occurred at Moorfields Eye Hospital, London, under the care of Mr. Robert Lyell, whose assistant he was at the time. Neuritis and optic atrophy preceded the pronounced exophthalmos. After some time sloughing of the cornea followed and the eyeball was removed. At this time the cyst wall was accidentally opened and the fluid gushed out and was followed by complete collapse of the growth. A microscopic examination of some of the fluid confirmed the diagnosis, as the scolices and hooks were plainly seen in large number.

Serous Cyst.—The integument has a glistening, pink color, slightly translucent, moderately tense, and not adherent to the tumor. The sizes of the cysts vary; they are not pointed, but oval in shape, having their greatest breadth immediately below the skin, while the small or pointed diameter lies buried deep in the orbit. Their point of development, apparently, is from the periosteum covering the nasal bone. They find their way to the

FIG. 190.—MALIGNANT ORBITAL GROWTH; GLIOMA. (Author's case.)

FIG. 191.—SAME CASE AS FIG. 190 AT LATER PERIOD.

surface, expanding where there is least constriction from the tissues, and are of exceedingly slow growth, never interfering with the motility of the eyeball nor movements of the eyelid. These cysts are detected in early life, and, no doubt, like the dermoid, are developed in the embryonic period. The cyst walls, which are thin, fibrinous, and elastic, cannot be easily dissected from the adjoining tissues.

The fluid contents of the sac are clear, yellowish, and of the consistence of honey. Microscopic examination reveals an oily fluid filled with fatty, granular masses, large oval cells, similar to mucous cells; no cholesterin crystals or dermoid *débris*.

Treatment.—The application of irritants externally, puncturing the cyst, injecting dilute tincture of iodin, signally fail to give

permanent relief. An incision of not less than 6 lines is made with a sharp-pointed bistoury, or Beer's knife, into the sac, making the wound in the horizontal direction, and the contents of the

FIG. 192.—SAME CASE AS FIGS. 190, 191; PHOTOGRAPH TAKEN ONE WEEK BEFORE FATAL TERMINATION.

tumor is emptied by gentle pressure. A point of nitrate of silver is then thoroughly applied to the inner walls of the cyst (great care must be observed to apply the caustic to the lower part of the cavity); by this procedure the inner walls are destroyed, thereby

creating two inflamed surfaces which become agglutinated, and the cyst is obliterated. A small pellet of lint is usually kept in the external orifice of the wound for three or four days to prevent closure, as the destroyed tissues will slough, and a slight discharge makes its appearance. For the first six hours after the operation cold dressings are applied; after this, boroglycerid. There is no reaction, the cavity healing rapidly.

The **vascular growths** are largely congenital and consist of telangiectatic and cavernous angiomata and aneuryisms. Pulsation is present in addition to the exophthalmos. They are slow in growth and are attended by very little pain, but should be removed when possible.

The **optic nerve** is occasionally the seat of a myxoma or myxosarcoma and is attended by exophthalmos, but very little disturbance of motility, owing to the situation of the growth. It enlarges very slowly and induces blindness from pressure upon the optic nerve. The condition may be recognized only by deep palpation. Simple myxomata are benign and do not tend to recur. Myxosarcomata, on the other hand, require removal of the eyeball and as much of the optic nerve as possible.

Kronlein's Operation.—The purpose of this operation is to expose the deeper orbital structures, especially tumors. It essentially consists of a temporary osteoplastic resection of the outer wall of the orbit. The operation is performed as follows: A vertical incision is made through the skin at the outer orbital margin. The incision begins at the temple, passes through the upper outer orbital margin, then describes a curve, until passing backward it again crosses the orbital margin, terminating in the temple above the zygoma, the periosteum being included. Both at the upper end of the outer margin of the orbit and close to the lower end the periosteum of the orbital surface of the outer wall is denuded up to the beginning of the zygomatic arch. Beginning at the anterior end of the inferior orbital fissure the orbital wall is chiseled through in an upward and outward direction to the external angular process of the frontal bone, then downward and outward, hugging the external surface of the malar bone just above the zygoma. Up to this point there has been a wedge-shaped resection. This piece of bone, together with the skin and muscles attached to it, is now retracted outward, thus expos-

ing the desired area. After the indications within the orbit have been met, and hemorrhage controlled, the triangular piece of bone with its attachments is replaced, the periosteum being approximated with catgut sutures, the skin with silk, and an aseptic compress and bandage applied.

The **orbital walls** may also be the origin of orbital growths. The periosteum may be circumscribedly or diffusedly hypertrophied, resembling a tumor in many respects.

Exostoses are also encountered, originating from the periosteum, usually at the upper border of the orbit. The cause is often injury. Some cases may be of syphilitic origin. They are slow in growth, and are extremely hard and firmly attached to the bone from which they spring. Removal by drilling the base of the growth is indicated. The possibility of syphilis in the etiology should always be considered, and a fair trial given to the mercurials and iodids.

Sarcoma of the orbital walls may occur as a primary growth, but is usually due to extension of the sarcomatous process from other tissues in the orbit. The pain, rapid growth, and exophthalmos are marked.

The **adjacent sinuses** may encroach upon the orbit as the result of inflammation or tumors. Orbital periostitis or cellulitis, or both, may follow acute purulent inflammation of the frontal, ethmoidal, or sphenoidal sinuses or the antrum of Highmore. Such cases are encountered with greatest frequency in the course of the infectious fevers, such as influenza, scarlet fever, and pneumonia. The acute orbital complications induce exophthalmos, pain, and impairment of motility resembling orbital tumors. They are less common than those following chronic empyema of the accessory sinuses.

Chronic empyema of the frontal sinus is probably the most frequent of the diseases of the sinuses adjacent to the orbit. It may follow the acute inflammation, but is more often chronic from the beginning. Persistent brow-ache and nasal discharge are constant, but are of no diagnostic importance, as they also accompany ethmoid disease. With the accumulation of pus within the sinus, caries and perforation of the bony wall ensue in an effort to afford a spontaneous discharge of the sinus contents. This process is slow, but is satisfactory as far as the sinus

is concerned. The dense periosteum and fascia of the orbit, however, prevent the exit of the pus from the orbit. As the purulent material accumulates in its new location the periosteum is raised and distended, so that it and the fascia with the discharged material form a tense fluctuating tumor to which the term *mucocele* is applied. The material within the cyst walls is at first true pus, but later, by precipitation and retrograde changes, becomes a somewhat thin mucoid fluid. The frontal sinus may also discharge itself anteriorly in the region of the eyebrow. In such cases the skin is likewise perforated and a fistula remains. The mucocele of frontal sinus disease by reason of its location induces exophthalmos downward and outward, and this may aid the diagnosis materially.

Treatment.—In all cases it is necessary to afford free drainage for the purulent material. All diseased portions of the bony wall should be removed and the sinus should be thoroughly antisepticized. In acute empyema an incision should be made in the inner third of the eyebrow and a small opening should be made in the bony wall beneath the supra-orbital ridge. The lining membrane of the sinus is opened and its contents removed by irrigation with a bichlorid-of-mercury solution (1–5,000). A probe should then be passed to determine whether or not a free communication with the nasal passages exists. The cavity of the sinus should then be packed with antiseptic gauze, which should be changed daily. Irrigation of the cavity should always precede the introduction of fresh gauze.

In chronic empyema of the frontal sinus there are two principal forms of treatment. In one the sinus is completely opened and all diseased bone and other material thoroughly scraped away, after which the cavity is packed with gauze and allowed to heal up from the bottom, thus obliterating the sinus. As originally performed this was attended by good results, but also by considerable deformity, so that it has since been modified, retaining the upper orbital margin and the periosteum. The injection of steam into the sinus has been employed for its obliteration. In the second treatment the sinus is carefully curetted and irrigated, after which a free communication is established between the frontal sinus and nasal passages. A rubber tube is passed through this opening to afford drainage. Irrigation is then practiced daily.

In both forms cure occurs, but a rather long period of time is required.

Osteoma of the frontal sinus occasionally occurs, and is usually located at the upper inner angle of the orbit. It is not infrequently associated with chronic empyema of the sinus. The growth is dense and possesses the usual characteristics of osteoma. Although extirpation is indicated, it must be remembered that the risk attending it is considerable.

Disease of the ethmoidal sinus may be followed by extension of inflammation to the orbital cellular tissue in acute cases, or it may induce a fluctuating tumor or mucocele at the side of the orbit. The nasal passages should always receive careful attention in affections of the sinus. In the chronic form a curved incision should be made from below the inner third of the eyebrow to the inner canthus, keeping to the inner upper side of the pulley of the superior oblique (H. Knapp). All diseased bone should be thoroughly scraped away and the cavity freely irrigated. The passing of a tube into the nose is necessary to maintain free drainage. Daily irrigation is also required.

Tumors of the ethmoid, such as carcinoma and sarcoma, are occasionally encountered and pursue their usual malignant course. The orbit is encroached upon by their growth, and exophthalmos is an early symptom. Removal of the growth should be performed if possible, but it seldom if ever succeeds in checking the affection.

The **sphenoidal antrum** in rare instances gives origin to bony tumors, polypi, and sarcomata that encroach upon the orbit. They are seldom diagnosed in their early stages, and frequently the first symptom noticed is blindness, most marked on the temporal side of the field. Examination of the nasopharynx at this period will reveal the presence of a sphenoidal growth. Removal of the growth is indicated, but is always difficult and often impossible.

The **maxillary antrum** or **antrum of Highmore** may also be the seat of malignant tumors that may erode the floor of the orbit, causing the eyeball to be displaced upward and inward or upward and outward. The growth within the superior maxilla enlarges in all directions, so that the cheek is broadened, the nose is displaced, and the roof of the mouth is pushed downward. Pain is

present, due to the pressure and irritation upon the fifth cranial nerve. Nasal discharge is sometimes present. The treatment consists usually in resection of the superior maxilla, and the prognosis is unfavorable.

Encephalocele or hernia of the brain is occasionally encountered as a cause of exophthalmos, and should not be confused with the various ocular tumors. It is due to a prolapse of a portion of the dura through some congenital aperture in the orbital roof. It is usually cystic in character, containing cerebrospinal fluid, although in some cases brain matter is inclosed. The tumor is most often situated at the upper inner angle of the orbit and may be reduced by pressure. Symptoms of increased intracranial pressure, such as convulsive movements and twitchings, accompany its reduction, and are of diagnostic significance. The condition is congenital and is not amenable to treatment. The prognosis is very unfavorable, as the affection ultimately terminates in death.

Intracranial tumors seldom invade the orbit, but such an occurrence should be always regarded as a possibility. Tumors of the middle fossa of the skull have been recorded to have pushed their way into the orbit through the sphenoidal fissure and optic foramen. Such tumors are usually recognized by the ocular symptoms they induce, such as hemianopsia and choked disk, long before there is any extension to the orbit. Treatment is of no avail in this class of cases, and the outlook is hopeless.

Dislocation of the eyeball is an infrequent condition, but deserves consideration, as the attending exophthalmos may cause it to be confused with some grave orbital condition. More or less injury to the optic nerve and consequent impairment of sight usually attend this injury. The globe should be reduced by pressure, and maintained in position by a pressure bandage.

Diagnosis.—From the foregoing descriptions it may be readily seen that exophthalmos is an accompaniment of a number of affections of the orbit and adjacent structures. Most of these are serious conditions, and the protrusion of the eyeball in such cases is unilateral. Bilateral exophthalmos is seen in myopia and exophthalmic goiter. The distinction between these affections rests upon the condition of the refraction and the presence of increased cardiac activity and enlargement of the thyroid gland in the lat-

ter condition. Other symptoms are present in exophthalmic goiter, but these are the most characteristic. In all affections limited to one orbit the protrusion of the eyeball is monolateral. The exophthalmos is directed straight forward in inflammatory conditions of the orbit, edema of the surrounding structures, ocular paralyses, and exophthalmic goiter. This should be constantly borne in mind, as the direction of the exophthalmos is oblique in orbital tumors due to the uneven pressure they exert. Orbital tumors grow from one wall of the orbit and push the globe to the opposite side as well as forward. Tumors of the optic nerve and others situated at the apex of the orbit produce no lateral displacement. Exophthalmos slowly produced is suggestive of benign growth, while that induced rapidly indicates cellulitis or some very malignant tumor.

To determine the character of the condition inducing the exophthalmos in a given case it is necessary to employ palpation. This determines the location and consistency of the growth if any is present. Comparison with the unaffected orbit should not be neglected, as it aids the examination materially. Tenderness and pain on palpation nearly always indicates inflammatory conditions, while the presence of a thrill points to vascular disturbances.

Visual disturbances are of value in the diagnosis. In the early stages diplopia is constant, but as the pressure increases upon the optic nerve blindness follows in the affected eye and the diplopia is completely effaced. In tumors located upon the optic nerve or very far back in the orbit, optic neuritis and subsequent optic atrophy may occur before any exophthalmos is produced.

Pain is present in nearly all cases due to the pressure upon the fifth nerve, but in sarcoma and carcinoma it assumes a peculiar character, distinctive of those tumors anywhere in the body.

The impairment of ocular motility may also aid in locating the cause of the exophthalmos. In tumors situated within the muscle cone, such as those affecting the optic nerve, perfect muscle equilibrium is maintained. If the tumor is situated outside of the cone there is loss of motion of the muscle corresponding to the side on which the tumor is located.

Pathologic conditions of the adjacent sinuses inducing exophthalmos require most careful examination for their recognition.

The presence of a mucocele or a fistula always indicates chronic disease of the sinus, with which it lies in contact or communicates. The tumors of these sinuses encroach upon the orbit only from one direction, that corresponding to the sinus from which they originate. An examination of the nasal passages should also be made in these cases.

Intracranial growths extending to the orbit may be distinguished from other growths by the optic neuritis, optic atrophy, and the various localizing signs.

The character of a tumor in any case is seldom determined before its removal, excepting syphilis, in which the history and the application of more modern discoveries may assist.

Treatment in General.—Tumors limited to the eyeball require enucleation. Cysts of the orbital tissue necessitate excision. Bony tumors growing from the orbital walls may be excised except when involving the roof of the orbit. Inflammation of the cellular tissue should receive the ordinary treatment for inflammation, care being taken to perform incision early. Inflammatory disease of the adjacent sinuses is best treated by affording free drainage through the nose. Exophthalmic goiter should receive the ordinary treatment indicated in such cases. Malignant tumors arising from or attacking the eyeball, orbital tissue, bony walls, or adjacent sinuses require exenteration of the orbit. Excision of the bone in these cases of bony origin is also employed. The application of the X-ray may be of value in those cases unaccompanied by metastasis. Occasionally obscure orbital growths are encountered that are retarded by antisyphilitic treatment, and in all cases a fair trial should be given the mercurials and iodids. When tubercular tumors are suspected the serum test should be employed.

Prognosis.—Unilateral exophthalmos is always an unfavorable sign.

The accompanying pressure induces disturbances of muscle equilibrium and impairment of vision from changes in the optic nerve. In more severe cases the eye is entirely lost, and in malignant tumors life is endangered.

Enophthalmos is a condition in which the eyeball is retracted. This may follow emaciating diseases, but is most marked after traumatism. It may be induced by paralysis of the sympathetic,

cicatricial contraction, fracture of the orbital bones, and palsy of the inferior oblique, and seldom makes its appearance until several days or weeks after the receipt of the injury. It may follow the spontaneous retrogression of a pulsating exophthalmos. Treatment is of no avail.

CHAPTER XX

THE OCULAR MANIFESTATIONS OF GENERAL DISEASES

OCULAR MANIFESTATIONS OF CONSTITUTIONAL DISEASES

THE affections of the economy as a whole that influence the condition of the eye most often are syphilis, tuberculosis, Bright's disease, diabetes, rheumatism, leukemia, chronic intoxications, hysteria, impaired metabolism, intestinal parasites, pyemia, and consanguinity of parentage.

Syphilis.—The relation between *syphilis* and the various diseases of the eye is well known, acutely inflammatory affections of the anterior segment of the eye being common in the early stages, while chronic affections of the posterior segment are particularly distinctive of the later stages of the disease. Gummata may induce exophthalmos when located in the orbit, and papillitis if situated along the course of the optic nerve fibers or in the brain. Palsy of the extra-ocular muscles is often due to syphilis. Chronic interstitial keratitis is nearly always a manifestation of inherited syphilis.

The recent work on the serum diagnosis of syphilis by the Wassermann reaction (see article by Carroll E. Edson, read at the meeting of the Colorado State Medical Society, Denver, Col., September 12, 1908) is of considerable value in the detection of syphilis and parasyphilitic diseases in so far as they affect the eye. The reaction is prevented by antisyphilitic treatment. A positive reaction means syphilis whether acquired or inherited, but a negative reaction does not have an equal negative value. The delicacy and complexity of the technic as at present developed render the test difficult of universal application. "*One hundred ophthalmic cases from the eye clinic in Berlin gave in every instance a reaction corresponding to the clinical diagnosis.*" Leber's statistics (*Berliner Klin. Woch.*, No. 12, November,

1909) show that in 160 cases, among those that were clinically syphilitic, 92 per cent were positive in the reaction. Cohen (*Berliner Klin. Woch.*, No. 18, 1908) gives the following table:

	No. of Cases	Positive	Negative
Iritis	23	7	..
Parenchymatous keratitis	9	6	..
Choroiditis	3	2	..
Optic atrophy	6	4	..
Neuro-retinitis	4	1	..
Choked disk	5	..	5
Paralysis of muscles	5	1	..
Reflex irido-plegia	1	..	1
Ophthalmoplegia	1	..	1
Central scotoma	1	..	1
Atrophy of retina	2	1	..
Atrophy of iris	1	..	1
Vascular macula of cornea	1	..	1

The discoveries of Schaudinn, Hoffman, and Wassermann therefore promise much.

The "treponema pallida" (spirocheta pallida) in addition to being found in the primary, secondary, and tertiary lesions of acquired syphilis, and abundantly in the viscera of hereditary syphilis, has been demonstrated in the experimental syphilitic keratitis of dogs, the cornea being the only point in which dogs can be inoculated.

The technic for the detection of the organism, either by stained films or with a dark ground illuminator, will be found in works devoted to microscopical investigations.

Tuberculosis seldom affects the eye as an inflammatory condition or growth of its various structures, although such conditions have been described, but usually predisposes toward the ordinary affections of that organ by the marked lowering of body tone it induces. The so-called "scrofulous diathesis," although indefinite in its pathology, is a well-known clinical condition, and it is in these cases that chronic inflammatory diseases of the anterior portion of the eye are most frequent. The value of the dilated pupil and glistening eye has been commented upon as an early symptom.

Calmette's Ophthalmo-Tuberculin Reaction.—Calmette and Wolff-Eisner, although working independently, were the first to propose the conjunctival reaction from tuberculin as a means of

diagnosis for tuberculosis. A marked reaction was at first obtained by Wolff-Eisner, who in the beginning of his investigations used a 10-per-cent aqueous solution of tuberculin. Calmette reduced the strength to 1-per-cent aqueous solution of dried crude tuberculin which had been precipitated by 95 per cent alcohol, dried, and then redissolved in water. The object of this procedure was to prevent irritation of the conjunctiva by removing the glycerin and extractives. According to Calmette (*Presse Med.*, June 19, 1907), the reaction occurs as follows: "Beginning from the third hour after the instillation into the eye of a 1-per-cent aqueous solution of tuberculin, the eye became reddened and within several hours showed all the manifestations of mucopurulent conjunctivitis of varying intensity. The fastigium was observed within six or seven hours after the instillation. All vestiges of inflammation had disappeared within two or three days. The procedure is free from danger and is the source of hardly any discomfort to the patient."

While untoward results from the instillation of tuberculin into the eye have been comparatively few, a number of cases have been reported in which the reaction has been associated with ulceration of the cornea, ulcerative and vascular keratitis, excessive irritation of the conjunctiva, and in some cases permanent injury to sight. Opinion is as yet somewhat divided as to the ultimate status of the procedure. The author had adopted the employment of Calmette's test at the Medico-Chirurgical Hospital, but did not feel justified in continuing it.

Bright's disease nearly always produces ocular conditions particularly distinctive of it alone. Loss of vision, complete or partial, may be uremic in character, and is characterized by its sudden onset, with the preservation of the pupillary reactions. It frequently disappears when the blood is relieved of the poison by sweating and purging. Most observers agree that there are no ophthalmoscopic changes to account for it. Albuminuric retinitis is an early and very characteristic symptom of the condition. Puffiness of the eyelids upon rising in the morning is regarded as an early symptom of renal dropsy.

Rheumatism is particularly prone to induce iritis, but may also be a contributory factor in the production of other ocular diseases, such as episcleritis and tenonitis.

Diabetes is often associated with cataracts, and less frequently with retrobulbar neuritis and retinitis. Sudden amaurosis, similar to that characteristic of uremia, may occur. Optic atrophy and paralysis of the muscle of accommodation have been observed.

Masked gout may be characterized by hot, pricking eyeballs, accompanied by a sensation as if sand were in the conjunctiva. Sudden transitory episcleral congestion, lasting from a few hours to a day, with a tendency to recurrence, is common. The latter may be a forerunner of retinitis, retinal hemorrhages, and even glaucoma.

Extra-ocular palsy, neuroparalytic keratitis, iritis, and hemorrhagic retinitis are also occasionally found in connection with diabetes; xanthoma, a growth of the eyelids, is often due to this disease.

Chlorosis shows a notable pallor of the disk and fundus or intractable muscular asthenopia. In addition to a grayish lusterless nerve head there is found a broadening and pallor of the retinal veins.

Leukemia is characterized by peculiar eye-ground changes; the whole fundus is unusually pale yellow in appearance in both eyes, and there is a marked tendency toward hemorrhage, the remnants of which are found in all stages of absorption. Chronic iritis, vitreous opacities, and exudations into the choroid and optic nerve have been observed in this disease.

Pernicious anemia is also attended by a distinctive fundus picture. There is a diffuse inflammation of the retina with marked edema, pallid color of the blood-vessels, and a dirty greenish-white appearance of the optic disk intensified by the yellowish background of the rest of the fundus. Round or flame-shaped hemorrhages are a fairly constant finding.

Chronic intoxications that affect the eye include alcohol, tobacco, quinin, lead, methyl alcohol, etc., all of which induce chronic retrobulbar neuritis and consequent alterations in vision.

Hysteria is attended by marked activity of the extra-ocular muscles, and not infrequently is associated with temporary blindness. In hysteric and neurasthenic individuals dilatation of the pupil is nearly always present. (See Nervous Diseases.)

... **metabolism** is responsible for the continuance of a
... inflammatory conditions of the conjunctiva.
... in whom improper feeding is a constant ac-
... an example may be mentioned phlyctenular
... that the *muscae volitantes* arise from this
... marked during periods of indigestion.

... **parasites** may be considered as general affections
... are liberated and allowed to enter the blood
... peripheral portions of the body. Should
... the eye and develop there they may destroy
... This is a very rare condition, the cysticer-
... worm, being most frequently found.

... after childbirth, occasionally gives rise
... the eyes. One eye is usually involved,
... of panophthalmitis.

... is always attended by some vague
... as is evidenced by the peculiar condi-
... children. As a prominent example may
... mentosa.

... often observed to be affected by inter-
... disease, and lamellar or zonular cata-
... between these affections is not well under-
... likely that the nutritional disturbances
... of great importance.

... condition characterized by profuse hemor-
... wound or injury, may be followed by
... al hemorrhage with subsequent reti-

... affection, may involve the eyelids or
... of the visual fields and amblyopia.
... manifestations are subconjunctival and
... ulcers, and parenchymatous keratitis.

...STATIONS OF DISEASES OF THE ...GESTIVE TRACT

... atory diseases of the eye are due to
... of which are affections of the teeth.
... ection between the distribution of the

fifth nerve and the nerves of the eye. Affections of the eye attributable to diseased teeth occur frequently; often the family physician is ignorant of the cause, and the disturbing member is allowed to remain.

Dental affections provoke ocular troubles in two different ways: (1) By inflammation or irritation of the trigeminal nerve due to dental affection, causing reflex troubles in a manner similar to that in which neuralgia of the fifth nerve or tic douloureux is produced. (2) By the extension of an inflammatory process of the dental root toward the maxillary sinus, and thence toward the orbit by continuity and contiguity of structure.

The most frequent reflex ocular troubles are pronounced injection of conjunctiva with epiphora from hypersecretion. In children the relation between dental affection and keratitis and phlyctenular conjunctivitis is more noticeable, this being partly explained by the irritation of the trigeminal nerve.

Schmidt, who has given much study to the paresis of accommodation following dental affections, states that in 92 cases of dental disease observed by him the amplitude of accommodation was 73 times less than that encountered at the same age by other observers, especially Donders. The disappearance of the dental affection induced coincident disappearance of the paresis of accommodation. The amplitude of accommodation being greater in young people, the decrease is more pronounced and more appreciable. The decrease of accommodation occasioned by dental irritation, according to statistics, is found to be more pronounced on the diseased side. Owing to a lack of study devoted to this branch this transient paresis of accommodation in the majority of cases remains unnoticed. Some authors claim that paresis of accommodation is usually of reflex nature; that the irritation of the vasomotor nerves of the eye provoked by a diseased tooth, increases the tension of the eye; the acceptance of this theory is by no means general. Jacobson considers the cause of this paresis to be due to the relaxation of the muscle of accommodation. Pain in the dental nerves is frequently seen in keratitis and cyclitis, and conversely in dental neuralgia there is found some hyperesthesia of the nerves of the eye, which makes the contraction of the muscles of accommodation very painful. It is impossible for us to explain the fact that irritation of a sensory nerve may dimin-

ish or even suppress the energy of a motor nerve. We know that dental pains and irritation of the trigeminal nerves cause an increase of the intra-ocular tension and often produce attacks of acute glaucoma where there is a predisposition to neuralgia.

Children predisposed to toothache frequently develop chorea, limited particularly to the orbicularis muscles.

Dental affections produce reflex symptoms on the side of the facial nerve—for example, blepharospasm and chronic contraction of the orbicularis muscles of the eyelids.

It is important, especially when the symptoms seem vague, that inquiry be made as to condition of the teeth, in order that all obstacles that may be in the way or impede improvement may be removed. There are many instances on record where the removal of a carious tooth was the means of restoring sight. Not infrequently abscesses develop in the lid as the result of abscesses around the teeth, especially the eye teeth. The author has had hypopyon develop in a cataract patient eight days after extraction of the lens coincidently with an abscess of a tooth. The true relation between these structures, however, is not clear.

Other complications of dental pains are amblyopia and amaurosis. These symptoms disappear after extraction of the offending teeth. In such cases it is not uncommon to find peripheral contraction of the field of vision, pain in the eyes upon reading, dazzling by intense light, and the appearance of the complementary colors, especially when the sight is concentrated. The ophthalmoscope shows nothing abnormal except occasionally a slight haziness in the posterior portion of the retina around the papilla.

The contracted field of vision, amblyopia, and amaurosis are explained by the reflex constrictions of the vessels of the retina—these symptoms being analogous to those observed in the affections of the nose.

The author recalls two cases of iritis where the extraction of several teeth produced a lessening of the inflammation with its gradual disappearance.

Wicherkiewicz reports the following observations: Sometimes after the extraction of a diseased tooth, gangrene of the eyelids and orbital abscesses appear; the inflammation attacking the meninges, the patient dies from meningitis in some cases,

proving that thorough antisepsis should be observed even in the extraction of a tooth.

Affections of the eye of dental origin may be reflex, inflammatory, or both. The combined form is probably more frequent, the proportion of the constituents varying in each case.

M. Parinaud has demonstrated that in children of five or six years, when they are beginning to lose their deciduous teeth, and also in adults, dental lesions, not always apparent, may be the starting-point of osseous or periosteal changes of the inferior orbital border, of fistulæ in the lacrymal sac, or lower lid, and also periostitis of the nasal canal.

It is always well, on the eve of an operation, to make inquiries as to the condition of the teeth, as well as to neuralgia, especially when the patient is to undergo a cataract operation.

Pharynx.—Ocular complications following pharyngeal affections may be attributed also to reflex troubles by irritation of the trigeminal nerve. The presence of foreign bodies in the pharynx, such as fish bones, bread crumbs, etc., provoke reflex irritation, watering and contraction of the eyelids on the side corresponding to the affected part of the pharynx, or to the tonsil where the foreign body is located.

Adenoid vegetations in the nasopharynx are responsible for certain apparently obscure ocular affections. Quite recently a case came under the author's observation in clinic that was hastily diagnosticated by him, and subsequently by other ophthalmologists in this city, as optic neuritis possibly due to an intracranial growth. Some time later the patient consulted Dr. S. Lewis Ziegler, who removed a number of adenoid growths from the nasopharynx, after which the ocular disturbances rapidly subsided.

Ziem observed after tonsillitis and adenoid vegetations of the pharynx, reflex ocular troubles—watering, blepharospasm, conjunctivitis, etc.

One of the complications observed several times after diseases of the pharynx and tonsils (particularly diphtheria) is the diminution of the amplitude of accommodation.

Stomach.—Affections of the stomach may cause ocular symptoms in four different ways:

1. By general weakness, causing lack of nutrition and alteration of the blood.

2. By absorption of the toxic elements, the result of improper digestion and assimilation of food products.

3. By congestion of the brain and the organs of vision, induced by circulatory troubles consecutive to abdominal plethora.

4. By reflex irritation of the sympathetic intra-intestinal plexus (plexuses of Auerbach and Meissner), affecting the organ of vision.

Nausea alone, or combined with headache, is frequently relieved by suitable refraction.

The author has observed in cases of dyspepsia and chronic catarrh of the stomach, muscular asthenopia, fatigue of the retina, photophobia, and perception of complementary images provoked by brilliantly lighted objects. It is probable that all these phenomena are but the manifestation of the general weakness of the economy. In those attacked by diseases of the stomach there is sometimes seen an attack of acute and subacute glaucoma. It is probable, although not yet certain, that weakening of the energy of the general circulation predisposes to circulatory ocular troubles. As to stomach or intestinal hemorrhages, more or less pronounced, it is a well-known fact that such occurrences give rise to certain ocular troubles. According to Förster, amblyopia from stomach troubles usually occupies the first place in order of frequency. Visual troubles follow hemorrhage some days after, showing that diminution of the quantity of blood is not the direct cause. Visual disturbances are frequently preceded by symptoms of cerebral anemia, such as weakness, frightful occipital pains, pallor, etc. Viewed by the ophthalmoscope, the retina is of a whitish opacity, extending all around the papilla, which is studded with small and numerous foci of hemorrhage. The improvement of amaurosis, caused by stomachic hemorrhages, is observed simultaneously with the resorption of the hemorrhagic foci and the disappearance of the retinal alterations, the outlines of the papilla becoming stronger and clearer, and the back of the eye at last resuming its normal condition.

Leber, Himly, and Galezowski quote cases of amblyopia following simple gastric irregularity, which disappeared after an emetic or any other treatment for the gastric embarrassment had been administered.

Intestines.—Patients weakened by prolonged or chronic diarrhea are, according to Förster, predisposed to chronic glaucoma. On the other hand, Wicherkiewicz observed an attack of acute glaucoma following polonged constipation. Chronic diarrhea gives rise to a general weakness of the body, affecting the muscle of accommodation as well as other muscular structures. Intestinal hemorrhages provoke the same troubles of the eye as those described when speaking of stomach hemorrhages. Intestinal knots may provoke amblyopia, amaurosis, and paralysis of the ocular muscles. These phenomena are generally attributed to reflex irritation produced by the volvulus. According to recent researches, it would be more proper or correct to treat these phenomena as symptoms of traumatic hysteria, induced by the intestinal affection. Straining at stool may give rise to intra-ocular hemorrhage.

Liver.—Hyperemia of the liver, while causing abdominal plethora, and consequently venous arrest in the brain, also gives rise to circulatory troubles in the organ of vision. The patients, especially those who work constantly at close range, complain of headache, vertigo, and frontal and orbital pains, all which phenomena are brought about by weakness of the muscle of accommodation. The amplitude of accommodation, which at the age of forty years is from 3 to 5 D., falls in these cases to 2 D. The patients are then obliged to wear their presbyopic correction at an age earlier than under normal conditions. When hyperemia of the liver is cured (by purgatives and alkalines) the ocular troubles disappear. Opacities in the equatorial part of the crystalline lens have been observed in cases of hyperemia of the liver. Ocular troubles are also frequently met with in patients suffering from jaundice, hepatic cirrhosis, hypertrophy, etc. The yellowish staining of the conjunctiva is one of the early signs of jaundice and is diagnostic in negroes. A similar staining of the eye-ground may be observed in these cases by using the ophthalmoscope with ordinary daylight for illumination.

Pancreas.—It is not certain whether ocular troubles are complications of disease of the pancreas. It should, however, be remembered that affections of the pancreas, as, for example, sclerosis, atrophy, and calculi, induce a particular form of diabetes mellitus, analogous to that artificially produced in animals by pre-

viously extracting the pancreas, and which may give rise to certain ocular troubles, especially retinitis.

OCULAR MANIFESTATIONS OF AURAL DISEASES

Some authors have noted optic neuritis, blepharospasm, nystagmus, paralysis of accommodation, and other oculomotor palsies after suppurative otitis media, and they believe that the ocular troubles can be caused by ear affections. It is more probable that these ocular troubles are provoked by the same causes, or are coincident with middle-ear disease, without being the consequence. Optic neuritis sometimes occurs as the result of an otogenous meningitis.

Styx reports a very interesting case of a young man of twenty-one, attacked by otitis media accompanied in the third week by fever, cephalalgia, vomiting, and constipation. Simultaneously there occurred on the corresponding side apparently slight optic neuritis and paralysis of the external oculomotor nerve.

Wiethe reports a case of orbital abscess complicating suppurative otitis media.

OCULAR MANIFESTATIONS OF GYNECOLOGIC AFFECTIONS

The connection between ocular troubles and affections of the genital tract in women has for a long time been the object of special study. Ocular troubles depending upon a lesion of the genital organs in man have been but partially studied, but there is sufficient evidence to warrant the conclusion that affections of the prostate in men probably play the same rôle in the development of reflex ocular troubles as diseases of the uterus in women.

Puberty.—Puberty plays an important rôle in the development of diseases of the eyes. According to Puech, affections of the eye at this age attain their maximum frequency. The development of phlyctenular keratitis, interstitial keratitis, pannus, affections of the uveal tract, the lessening of the sensibility of the retina, and optic neuritis may be frequently observed.

Menstruation.—Certain observers have noted the appearance of ocular troubles during menstruation. Finkelstein examined

the visual field during the menstrual period, and found the highest degree of peripheral contraction when the menstrual discharge was most abundant. After menstruation the eye returns to its normal condition. It is very important to recognize the fact that exacerbations of diseases of the eyes may occur during the menstrual period; the tendency toward relapses of chronic iritis at such times has long been established by Michel and Trousseau. Despagnet reported a case of iritis which recurred with each menstrual epoch; Trousseau described a case of iritis with hypopyon which made its appearance at each menstruation in a woman suffering with endometritis. This latter case also relapsed during the corresponding period in pregnancy. There is also a great tendency toward retinal hyperesthesia and its consequent alterations in vision during the menstrual period. Where there exists disease of the blood-vessels, menstruation may induce hemorrhages into the vitreous, retina, or optic nerve. Hasner reports the case of a young girl in whom total paralysis of the oculomotor nerve occurred at each period of menstruation.

Amenorrhea and Dysmenorrhea.—Jacobson observed ocular troubles caused by amenorrhea coming on after a chill of the lower part of the body. He also saw a case of acute optic neuritis with consecutive papillary atrophy and apoplexy of the optic nerve and of the retina following amenorrhea. A doubt arises as to whether the simultaneous occurrence of optic neuritis and amenorrhea in the preceding case was not casual. Hasner and others have described " bloody tears " in amenorrhea.

Menopause.—The menopause may occasion functional alterations in the organs of vision. Samelsohn described a case of amblyopia caused by the menopause, which increased to the point of complete amaurosis. By pressure upon the eye the patient experienced severe pain in the orbit. Under proper treatment the vision returned completely after some days. Mooren reports severe cases of optic neuritis developing during this period of life. Liebreich saw retinal hemorrhage after suppression of the menses. Changes in the eye during the menopause should not be confused with presbyopia, which is normal at this period. Conjunctivitis has been frequently seen.

Venereal Abuse.—Masturbation, according to Power, may determine in young girls photophobia, weakness of the muscle of

accommodation, asthenopia, and chronic conjunctivitis. It is most likely that these ocular troubles are dependent on hysteria or neurasthenia, engendered, occasionally, by venereal abuse. The author has observed two cases of intense photophobia with failure of accommodation and alterations of vision in young girls directly traceable to masturbation, and which entirely disappeared when the pernicious habit was broken up.

Pregnancy.—During pregnancy there is an increase in the pigment of the skin, including the eyelids. Retinitis, cephalalgia, and gastric pains may develop, as a result of the albuminuria and kidney changes of pregnancy; in a great number of cases these conditions may be regarded as precursors of eclampsia. The presence of albuminuric retinitis during pregnancy may oblige the physician to produce premature labor, the result of which after a short time is the restoration of sight. De Lapersonne observed a case of albuminuric retinitis in a woman six months pregnant. He produced premature labor, and seven or eight days later the visual acuity was again normal. A similar case was reported by Dr. A. L. Hudders, of Philadelphia. Albuminuric retinitis accompanied by detachment of the retina does not give a favorable prognosis, as incurable blindness remains in the majority of cases.

The uterus in a pregnant state may provoke ocular troubles analogous to those produced by uterine diseases. The most probable theory of these reflex troubles is that of Brown-Séquard —in which the appearance of vasomotor troubles is believed to be consecutive to irritation of the sympathetic system. This theory also explains contraction of the field of vision, weakness of the muscle of accommodation, lacrymation, and development of exophthalmic goiter during pregnancy. Amblyopia during pregnancy is undoubtedly always the result of albuminuric retinitis.

Weakness of the muscle of accommodation may show itself in the first months of pregnancy and may end in paralysis of accommodation; sometimes, on the contrary, this phenomenon may not occur until confinement.

Amaurosis may be the result of violent hemorrhages, developing during pregnancy or after confinement.

The development of hemiopia consecutive to very severe hemorrhage (after confinement) has sometimes been observed. Che-

vallereau reports the case of a woman in whom the extraction of the adherent placenta had invoked violent metrorrhea, the following symptoms being present: Six days after confinement there appeared high fever; at the end of sixteen days partial optic atrophy occurred, together with loss of memory of substantives; improvement of aphasia began at the end of six weeks; the patient then found that the field of vision had been reduced about one half. Two years later complete hemianopsia was established.

During puerperal fever the eye may become the seat of embolisms in the retina and septic choroiditis, causing blindness and atrophy of the ocular globe.

Dangers of Parturition to the Eyes of the Child.—In the case of the mother, temporary dimness of vision, or even blindness, may occur independent of eclampsia. Parturition may cause complications not only in the mother's eyes, but also in those of the child. The eyes of the child may be infected in its course through the vagina and attacked by ophthalmia neonatorum, already fully discussed in another chapter of this work. Cases have been reported in which one of the eyes of the child was wounded in the use of forceps. Paralysis of the facial nerve by compression with the forceps is the principal affection the physician encounters, but with proper treatment it can generally be cured.

Pajot described very slight ecchymosis of the superior eyelid, also produced by compression of the forceps, and which may be the starting-point of dermatitis of the eyelids.

Bouchet has seen several cases where compression caused fracture of the frontal bone and exophthalmos which were cured without either paralysis or convulsions ensuing.

Schroeder, after using forceps in a primipara, found exophthalmos and hemorrhage in the anterior chamber of the eye. The autopsy revealed hemorrhage into the orbit (hence exophthalmos) and detachment of the dura mater, separated from the bone by the extravasated blood.

Edema and cicatricial ectropion have been observed by Stanheim as the result of forceps delivery.

The forceps may also cause laceration of one or more muscles of the eye. The result always will be paralysis of the said muscles, recognizable even after several years.

Cases have been reported where both eyeballs were permanently destroyed by a most unfortunate application of the forceps.

Diseases of the Ovaries.—Diseases of the ovaries may induce ocular troubles not connected with hysteria or neurasthenia. Only one case has been reported in favor of this hypothesis; which was an attack of glaucoma following puncturing of an ovarian cyst.

OCULAR MANIFESTATIONS OF AFFECTIONS OF THE MALE GENITAL ORGANS

It may well be supposed that there is a relation between ocular troubles and affections of the genital organs in man; nevertheless, but very few serious observations exist to place this relation beyond doubt. If there be a relation between the two, it is a well-known fact that this quite frequently escapes the attention of the attending physician.

It has been noticed recently that affections of the genital organs cause a disturbance of the functions of other organs than those of vision. Preyer has proved that certain diseases of the stomach, treated for a long time without the least success, were cured or improved after curing the affections of the sexual organs, which gave rise to them by reflex channel.

Masturbation or seminal loss may be reflected in the eye in two different ways:

1. In causing the development of neurasthenia, it engenders functional disorders of sight, which are but the partial symptoms of nervous diseases.

2. In weakening the whole economy, it does not exempt the organs of vision.

H. Cohn and Power, during their special researches in ocular troubles in onanists, discovered that those abandoned to masturbation are afflicted with floating specks, photophobia, and that they complain of accommodative asthenopia comparable to that produced in affections of the womb (hysterical copiopia); reading is very fatiguing; amplitude of accommodation is diminished, and spasms of the eyelids exist. It was also noticed that the patient had a staring look and a large or well-dilated pupil. The influence of the genital tract in the production of functional dis-

orders of the eye was recently exemplified by two men who consulted the author for intense photophobia, retinal hyperesthesia, and failure of accommodation. After exhausting the usual therapeutic measures for these conditions, and without any improvement, urethral sounds were passed under my direction by Dr. S. L. Gans, of the Medico-Chirurgical Hospital, dilating the urethra to its fullest caliber, after which prompt relief was afforded.

An inflammation of the conjunctiva which resists all manner of treatment, and which is similar to inflammations of the pharyngeal and other mucous tracts, is frequently met with in these unfortunate individuals.

At the present time it cannot be positively said that onanists are threatened with retinitis, atrophy of the optic nerve, etc., in their old age, for the reason that the connection between such conditions has never been proved.

By some authorities it is claimed that amblyopia is the result of masturbation, although this also has never been proved. It is probable that in a certain number of cases of amblyopia the latter is caused by weakness of the muscle of accommodation, due to reflex influences from the genital organs.

Milliken observed a case which proved that coitus may accidentally produce eye troubles. When arteriosclerosis exists, coitus may augment the action of the heart and encourage the development of cerebral hemorrhage; it is an indisputable fact that apoplectic fits have often been caused by coitus. In those cases of sudden death during sexual intercourse it is probable that the primary cause is cerebral hemorrhage, and this is no doubt preceded in many instances by retinal hemorrhages. When the hemorrhage is not great enough to induce death, incurable visual alterations are frequent. In Milliken's case, left homonymous hemianopsia occurred during coitus, probably produced by meningeal apoplexy of the left occipital lobe.

Exophthalmic goiter may occur in the female during an affection of the genital tract; in the male, it may be produced by an analogous cause—but this cause is so seldom considered that it probably often escapes the detection of the attending physician.

By some authorities it is claimed that affections of the prostate in the male may give rise to certain nervous reflex symptoms

similar to those seen in the female attacked by disease of the womb. Cataract, choroiditis, conjunctivitis, etc., have been frequently noticed in men with enlarged prostate glands and other affections of the urethral tract, and when properly treated the eye symptoms promptly improved, and even disappeared altogether in a number of instances. Gonorrheal ophthalmia, referred to in another chapter, one of the most serious affections the eye can be subjected to, is produced by infecting the eye with the gonococci of the urethral discharge. The treatment, as well as the care of the patient, in such an affection has been fully discussed in another chapter of this work.

OCULAR MANIFESTATIONS OF INFECTIOUS DISEASES

Cerebrospinal fever is frequently accompanied by pronounced ocular symptoms due to the irritation of the cranial nerves by the inflammatory exudate on the meninges. Nystagmus, strabismus, ptosis, and irregularity and immobility of the pupils occur early in the affection, and later are followed by palsy of the muscles with blindness. As complications during convalescence there may occur keratitis, retinitis or optic atrophy.

Cholera is attended by no characteristic conditions of the eye during the height of the disease with the exception of the marked shrinking of the orbital tissues, causing the eyes to have a pronounced sunken appearance. During convalescence ulceration of the cornea is not infrequent.

Diphtheria is not infrequently attended by a diphtheritic inflammation of the conjunctiva, but is more often followed by paralysis of accommodation or palsy of one or more of the extra-ocular muscles.

Erysipelas sometimes extends to the skin of the eyelids, causing their closure, or is followed by desquamation, with loss of the lashes. It is sometimes accompanied by other ocular disturbances, as purulent dacryocystitis, corneal abscess, and purulent irido-choroiditis. Knapp has recorded a few cases of optic atrophy following severe attacks of facial erysipelas.

Septicemia and pyemia display a tendency to retinal hemorrhages and the lodgment of septic emboli in the choroid or retina with resulting suppuration of the eye.

Hydrophobia is attended by excessive motion at first, and later immobility of the eyeballs, due to involvement of the extra-ocular muscles.

Influenza is accompanied in typical cases by a catarrhal inflammation of the conjunctiva, which is characteristic.

Malaria is attended by conjunctivitis in the ordinary forms: yellowish discoloration of the conjunctiva in pernicious malaria and chronic retrobulbar neuritis in cases of long standing. Malarial keratitis, amblyopia, and paresis of the accommodation are of frequent occurrence. According to Poncet ocular involvement occurs in 10 per cent of the cases of malaria.

Measles is usually preceded in children by a period of one week or more in which there is a marked tendency to close the eyes and sleep. There is very often a marked conjunctivitis before the eruption. As the rash appears, photophobia, lacrymation, blepharitis, and tiring of accommodation follow, and soon an inflammatory condition of the conjunctiva may be detected.

German measles, or rötheln, is characterized by the occasional appearance of the rash on the lids.

Scarlet fever is seldom associated with any diseases of the eye during the height of the affection, but during convalescence corneal ulcerations and inflammations are not infrequent. Renal changes are followed by the characteristic eye-ground alterations.

Small-pox is not only liable to be accompanied by keratitis, iritis, etc., but the lesions, themselves, of small-pox are not uncommonly situated upon the cornea, causing irreparable damage to the structure. The same conditions are likely to take place in vaccinia and varicella. The author recently removed an eye of a young girl that had been entirely destroyed by small-pox.

In **tetanus,** as in hydrophobia, the muscles that control the ocular movements are likely to be involved with other muscle structures.

In **typhoid, typhus,** and similar low fevers, a condition known as *coma vigil* frequently occurs, in which the eyes are wide open and stare directly ahead, the patient being more or less comatose. Dilatation of the pupil, paresis of accommodation, with

asthenopia and extra-ocular muscle palsies, have been observed as sequels. Anesthesia of the cornea, phlyctenular ulcers, iritis, retinal hemorrhages, and optic neuritis are seen during the height of the disease. A peculiar dryness of the conjunctiva often occurs.

Acute miliary tuberculosis is very frequently characterized by the presence of tubercles in the retina, photophobia, and ocular palsies.

Yellow fever is distinguished at first by contraction of the pupil and conjunctival injection, but later the pupil dilates and the conjunctiva becomes yellow. The onset of uremia may be announced by blindness.

Whooping cough is nearly always attended by a subacute conjunctivitis, and sudden hemorrhage may occur into the conjunctiva as the result of severe coughing.

OCULAR MANIFESTATIONS OF AFFECTIONS OF THE LYMPHATIC GLANDS

In patients attacked by polyadenitis the development of small tumors like buttons in the iris and the choroid is sometimes seen. These tumors when situated in the choroid may determine clinical symptoms of disseminated choroiditis.

In a case of polyadenitis, [illegible] found small lymphatic tumors in the liver, the lungs, the brain, and small analogous tumors in the optic nerve as well as the oculomotor nerve. The ophthalmoscope revealed the presence of [illegible] on one side [illegible]. [illegible] of the [illegible] into the [illegible].

[illegible] these cases show [illegible]. [illegible] by the [illegible].

[illegible] of the tumors [illegible] in order [illegible] of the [illegible].

OCULAR MANIFESTATIONS OF DISEASES OF THE RESPIRATORY TRACT

The extension of chronic rhinitis up the nasal duct is often a cause of persistent conjunctivitis. Less common are the various inflammatory conditions of the lacrymal apparatus. Some observers have shown an intimate relation between certain forms of rhinitis and choroiditis. It is probable that there is a syphilitic constitution underlying such cases.

Following serious catarrhal affections of the respiratory mucous membrane there is often the appearance of herpes on the cornea. This is characterized by vesicles filled with thickened or slightly limpid substance. It appears immediately after the crisis of a fever, simultaneously with nasal and labial herpes, being accompanied by intense pain, watering, and slight pericorneal injection. The vesicles burst in time and ulcerations form in their stead. The loss of substance is considerable, especially in those cases where the ulcerations are confluent. The cornea is anesthetized in the affected areas. The eyelids and forehead remain intact, which distinguishes this affection from herpes zoster. Its duration generally is from a month to six weeks, and usually is unilateral. In a recent case under my observation herpes corneæ febrilis lasted four months. Among the most common ocular conditions due to extension of inflammation from the nose is dacryocystitis and conjunctivitis.

Following a violent cough (whooping cough, chronic affections of the respiratory channels, etc.) hemorrhages appear in the subcutaneous tissues of the eyelids and the conjunctivæ. These hemorrhagic foci are superficial, subepithelial, and are formed by the rupture of capillaries, which are found on the summit of the papillæ of the dermis. In some instances the hemorrhage is so considerable that the eyelids are of a bluish color.

Hemorrhagic foci appear in those killed by asphyxia, hanging, and strangulation, their importance being recognized from the standpoint of legal medicine.

Circulatory disturbances also cause retinal hemorrhage, as in pulmonary emphysema, emboli of the pulmonary artery, and cyanosis consecutive to respiratory troubles, where there is simultaneous formation of hemorrhagic foci in the retina and in the con-

junctiva. This is especially observed in cases where death has been preceded by symptoms of suffocation.

In the newly born cyanosed child hemorrhagic foci are seen in the posterior part of the retina, caused by difficulty of respiration and probably also by compression of the head during birth. Difficulty of venous circulation in chronic diseases of the lung (emphysema, for example) causes venous stasis in the retina, and can be readily distinguished by means of the ophthalmoscope. Thus in emphysematous patients dilatation of the retinal veins is very frequent. There is also sometimes in these individuals thrombosis of the central vein of the retina.

OCULAR MANIFESTATIONS OF DISEASES OF ADJACENT SINUSES

The anatomical relation between the sinuses of the anterior [illegible] latter quite prone to [illegible] disease. In the [illegible] frontal and [illegible] each forms a part [illegible] The [illegible] inflammations [illegible] Sometimes [illegible]

[illegible] OF DISEASES OF THE SKIN

[illegible]

these affections are described at length in the chapter on Diseases of the Eyelids.

A more interesting subject is the relation that exists between phlyctenular disease and vesicular eczema of the face. Their almost invariable simultaneous occurrence has led some observers to term the conjunctival condition eczematoid conjunctivitis. It is more than likely that eczema is merely a coincidence and arises from the same nutritional causes as the ocular condition, although occasionally it seems secondary to the ocular discharge. Both diseases, however, nearly always disappear at the same time.

The dermal manifestations of syphilis should always be sought for, as frequently the diagnosis of a previously obscure inflammatory case will be made clear upon the finding of some evidence of syphilis upon the skin.

It should also be remembered that pustular and vesicular diseases in the ocular region show a marked tendency to extend, and their extension to the eye is always attended by more or less destruction of tissue.

OCULAR MANIFESTATIONS OF CARDIOVASCULAR DISEASES

The effects of **anemia** or **plethora** have been considered fully in the chapter devoted to diseases of the retina. The eye is not always a true index of the amount of blood in the general system, for we frequently encounter a conjunctival hyperemia in the presence of a rather profound anemia. It is only in the more pronounced grades of general anemia or venous congestion that a corresponding condition of the retinal vessels is observed. When hemorrhages are present in the retina, vitreous, or conjunctiva, degeneration of the vessel walls is usually the predisposing, while permanent or sharp elevations of blood-pressure furnish the exciting, cause. This increase or diminution of the blood-pressure is not shown by any particular change in the intra-ocular pressure, as the compensatory balance is accomplished by an increased outflow of the ocular lymph. After a prolonged period of high pressure and its accompanying vascular and hematogenous change we find a tendency to spontaneous retinal hemorrhages, their absorption generally giving rise to the formation of white patches. The hemorrhages frequently recur

unless the high pressure and its underlying cause is corrected. After excitement or during exhaustion the disturbance of the central vasomotor tonus permitting a fall of arterial pressure, the retinal arteries are found to pulsate feebly and become visibly narrowed, also flat or ribbonlike, the papilla pales and a narrowing of the visual field with the onset of syncope. This also occurs in the amblyopia due to severe hemorrhage. After the lapse of a variable period, usually five to eight days, hemorrhages occur from changes in the vessel walls. These are comparatively harmless in the retina, but are productive of retrobulbar neuritis with subsequent atrophy when in the optic nerve.

In **left ventricular hypertrophy** of either cardiac, renal disease or arteriosclerosis and other affections characterized by high arterial pressure, we note a pulsation of the retinal vessels extending to the periphery of the retina. In a case of arteriosclerosis of an advanced grade recently studied by the author, in which the systolic blood-pressure ranged between 215 and 230 mm. of Hg., the retinal arteries presented a marked lateral instead of the usual vertical pulsation, as usually seen. The veins were marked by numerous ampulliform dilatations. With the reduction of pressure by rest, glonoin, and iodids, the pulsations diminished in intensity corresponding with the reduction of pressure.

In **aortic insufficiency** there is almost constantly a pulsation of the arteries occurring synchronously with the radial pulse. The marked character of these pulsations is dependent upon the high systolic pressure induced by an hypertrophied left ventricle and the low systolic pressure incident to the reflux of blood. This phenomena may be absent if a moderate grade of stenosis coexists or under the influence of rest and cardiac tonics. A similar condition has been rarely observed in exophthalmic goiter, profound anemia, and chlorosis.

Intense venous congestion, the result of the failure of compensation in the last stages of valvular heart disease, is noticeable in the eye. Thick sinuous arteries and veins, with hemorrhages, are frequent. In fatty degeneration of the heart there is not infrequently vascular deterioration with concomitant ocular hemorrhages.

Arteriosclerosis.—Since the functional capacity of every organ depends upon its proper nutrition and blood supply, and this

in turn is dependent upon a normal vascular system, it is obvious that arteriosclerosis is capable of producing pathological changes in any and every part of the economy. At first these changes consist of those of a functional nature; later, as the vascular changes progress, the organs become the seat of organic disease. The functional disturbances of the *eyes* incident to *generalized arteriosclerosis* are muscular fatigue, headache after use of the eyes, notwithstanding correction of refractive errors. Again, alteration of the tonus of the extra-ocular muscles, transitory ptosis, slight nystagmus, imperfect accommodation, and convergence occur. Spasm of the diseased vessels in the retina is frequently responsible for the temporary scintillating scotomata, color sensations, and specks before the eyes. "Paroxysmal amaurosis" is another symptom of arteriocapillary fibrosis due to the same cause. The latter condition may last for a few seconds to a few hours without visible ophthalmoscopic changes. In about 50 per cent of cases of general arteriosclerosis the retinal arteries present sclerotic changes. The sclerosed vessel may show a grayish shadow along its course, Gunn's vessels, or fusiform yellowish swelling corresponding to an atheromatous localized thickening, with corresponding contraction of the lumen. There will also be an evident thinning of the column of blood in the arteries, narrowing of the veins, and an ischemic appearance of the fundus. A thickening of the sheath of the nerve at the optic papilla is frequently observed with minute areas of colloid degeneration around the macula. (See chapter on Diseases of the Retina.) Moreover, as mentioned above, there may be lateral pulsations and flexion of the vessels instead of the vertical movements, as seen most typically in aortic insufficiency. As mentioned in the chapter on Diseases of the Retina, retinal and subconjunctival hemorrhages are frequent; these furnish us with information of great prognostic value, as a large percentage of these cases die after two years from apoplexy or cardiac dilatation.

The thickening and sclerosis of the internal carotid and ophthalmic arteries by pulsating against the intracranial portion of the optic nerve may alter the shape of that structure. Moreover, as there is a bony wall upon the opposite side of the pressure, a progressive atrophy of the nerve is inevitable. The atrophy may

be confined to one group of fibers, if the ophthalmic artery alone be involved.

Sclerosis of the carotid and vessels forming the circle of Willis may exert pressure in the region of the optic chiasm with a resulting hemianopsia.

Arteriosclerosis has been considered a cause of a number of ocular diseases, notably glaucoma, by its effect upon the drainage canals, retinitis circinata, and thrombosis of the central artery of the retina.

OCULAR MANIFESTATIONS OF AFFECTIONS OF THE THYROID GLAND

From the pressure which they exert on the cervical sympathetic, tumors of the thyroid gland may provoke dilatation of the pupil. In exophthalmic goiter, Graves', or Basedow's disease certain observers have demonstrated the fact that dilatation of the pupil may be brought about by exercising pressure with the finger upon the thyroid gland, even when it is not diseased. The exophthalmos or protrusion is not always easy of detection, as its development is usually very gradual. Comparison with photographs of earlier years are often necessary. Anterior staphyloma, lengthening of the antero-posterior axis due to myopia, or a natural shallowness of the orbits, must be differentiated. Although usually bilateral, unilateral cases have been reported (Mauthner, Fridenberg, and others). The degree of protrusion varies, being largely dependent upon the heart's action and resulting orbital congestion. The *von Graefe* sign, consisting of an impairment of the downward movement of the upper lid with the globe, is present in many cases; it cannot be considered as pathognomonic, as it has been observed upon the eyes of healthy individuals. The abnormal widening of the palpebral angle (*Stellwag's sign*), due to retraction of the eyelids, constitutes a very striking symptom; it is usually accompanied by an infrequency of winking. A diminution of binocular convergence, or the *Möbius sign*, is occasionally present; it causes the patient to suffer the usual symptoms of asthenopia. Palsies of the extra-ocular muscles, either singly or combined, are not infrequent. In feeble and emaciated subjects severe corneal ulceration may occur as a

result of the infrequent winking and extreme exophthalmos. Berger emphasizes the frequency of epiphora as an early symptom, due, in all probability, to the interference of the drainage mechanism of the lacrymal canals occasioned by the disturbance of the normal relations of the bulbus oculi within the orbit.

Usually the vision is unaffected. Other ocular conditions have been observed, but it is probable that these were mere coincidences, and not the result of the goiter. Simple goiter and other affections of this gland hinder the circulation of the blood in the jugular vein, and the venous stasis that results may cause, in predisposed subjects, attacks of glaucoma. Kirschbaumer has noted the frequency of glaucoma in patients suffering with goiter.

Landesberg has published an observation of cataract which was regarded as the result of a strumous cachexia. It occurred in a girl of twenty-five years, from whom Bergmann had extracted the thyroid gland two years previously. Soon after the operation had been performed epileptic fits developed, and one year later eye troubles became prominent. Two years after the ablation of the goiter the patient presented herself to Landesberg, who found in both eyes opacity of the anterior layers of the crystalline lens; in the right eye adhesions existed between the iris and the crystalline lens. After the cataract operation very fine opacities (dustlike) were observed in the vitreous body. Landesberg believed that the alterations of the vitreous had been produced by a chronic affection of the uveal tract. First came choroiditis (opacities of the vitreous body), then iritis (posterior synechiæ), and finally cataract. The alterations were analogous to those observed sometimes following typhoid fever, variola, erysipelas, etc.

For more complete details of the relation of the eye to general diseases the reader is referred to the valuable works of Berger, Knies, and Linnell on the subject.

CHAPTER XXI

THE PUPIL IN HEALTH AND DISEASE—THE OCULAR MANIFESTATIONS OF NERVOUS DISEASES

General Considerations.—The pupil is an aperture in the iris, the size of which depends upon variations in the mobility of the iris. Upon examination of the pupil in the ordinary light of the room, it will be seen to be circular in shape or oval, with the long axis usually at 90 degrees, and situated slightly to the nasal side of the center of the cornea. It appears absolutely black for the reason that no light is reflected from the retina, and it becomes red in color only when the interior of the eye is made a source of illumination, as in examination by means of the ophthalmoscope. The average diameter is about 4.14 mm. The pupils are usually equal, but occasionally the left is found to be the larger. The measurements may be taken by means of the ordinary millimeter rule or by means of the pupillometer, a disk of glass upon which circles of varying diameters are drawn. The pupillometer is held close to the eye, and the circle that corresponds to the circumference of the pupil indicates its size in millimeters.

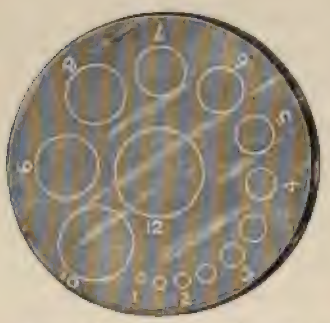


FIG. 193.—PUPILLOMETER.

The pupil is mobile, being capable of altering its diameters under the influence of various internal and external causes. It admits of three variations—rest, contraction, and dilatation—all of which depend upon the action of the circular and radiating fibers of the iris and their nerve supply. The condition of rest is only relative, being a condition midway between contraction and relaxation, a condition of muscle-tone, in fact, due to a recip-

rocal relation existing between the contractor and dilator nerves. Absolute rest is relaxation; but here, as elsewhere in the body, partial contraction is considered as rest.

In order to effect a departure in the condition of the pupil from that of rest, it is necessary to stimulate or depress either set of nerves supplying the iris. Contraction is induced by the stimulation of the oculomotor nerve and depression or paralysis of the sympathetic nerves, while dilatation results from stimulation of the sympathetic nerves and depression of the oculomotor nerve.

A knowledge of the details of these phenomena is of great value in determining the significance of the pupillary condition. Contraction is usually brought about by rays of light falling upon the retina in concentrated form. Afferent impulses are conducted thence by the optic nerve to the center for pupillary reaction. The existence of this center is undoubted, and it is believed to be located below the corpora quadrigemina in the anterior portion of the floor of the aqueduct of Sylvius. Contrary to what would be supposed, there is but one center governing both eyes, thus accounting for such a phenomenon as consensual reaction. Efferent impulses are dispatched from this center along the fibers of the third cranial or oculomotor nerve to the circular fibers of the iris or sphincter pupillæ, which, by their contraction, produce narrowing of the pupil or myosis.

In proof of this explanation of the manner in which contraction takes place, it has been shown that the pupil fails to contract when the retina is exposed to bright light if the third nerve has been severed, and that stimulation of the peripheral portion of the nerve alone will induce contraction under such circumstances. Further, stimulation of the center in the floor of the aqueduct of Sylvius will induce contraction in the absence of light, and the removal or destruction of the center will render light thrown upon the retina ineffectual in bringing about pupillary contraction. There is also some intrinsic ganglion in the iris itself, as is shown by the contraction that sometimes occurs when the eyeball is removed. The presence of some depressing influence upon the sympathetic nerves supplied to the iris is also necessary to bring about contraction of the pupil.

Dilatation of the pupil is brought about by contraction of the radial fibers of the iris and of the blood-vessels of the iris, the

latter causing a condition of temporary anemia in that structure. The pathways for the afferent impulses in this phenomenon are various and include the optic, the trifacial, and the sympathetic nerves throughout the body. The efferent impulses are conducted by the sympathetic nerves. The center for dilatation is situated in the anterior portion of the floor of the aqueduct of Sylvius just behind the center for contraction. The efferent impulses are then conducted to the medulla oblongata, and from there to the inferior ciliospinal center in the upper dorsal or lower cervical cord. This center is believed to be capable of governing dilatation of the pupil independent of the center in the brain. From this center the impulses travel along the roots of the upper dorsal and lower cervical spinal nerves to the *rami communicantes,* and thence to the upper thoracic ganglion. The sympathetic nerve carries the impulses from this ganglion into the skull following the course of the great blood-vessels, eventually reaching the iris. The nerve is in close communication with all the nerve-filaments of the iris—namely, the ciliary ganglion, the short ciliary nerves, the oculomotor nerve, and the ophthalmic division of the fifth nerve. That the sympathetic nerve is concerned in the dilatation of the pupil is proved by the marked contraction that follows division of the nerve and the subsequent dilatation that follows stimulation of its peripheral portion. Although dependent to a large degree upon the influence of the sympathetic nerve upon the blood-vessels of the iris, it is not entirely so, as has been shown by the dilatation that may be induced in the bloodless eye.

The local action of certain drugs when instilled into the eye has further demonstrated that the mobility of the pupil is also governed by an intrinsic ganglion resident in the iris itself.

Dilatation of the Pupil.—This occurs in fright, coma, emotion, aortic regurgitation, and anemia. According to the investigations of Fuchs, Schwalbe, Everbusch, and others, a dilator pupillæ muscle does not exist, the consensus of opinion appearing to be that dilatation of the pupil probably depends to a great extent on an inhibitory action of the sympathetic (Gaskell, Jessop, etc.).

Unilateral dilatation of the pupil may be the result of traumatism to the musculature of the iris or to the nerves supplying

it. It occurs in atrophy of the optic nerve where the transmission of the light impulse is interfered with; also in glaucoma and from drugs.

Bilateral dilatation of the pupil, besides the conditions already mentioned, may be paralytic or spastic in character.

FIG. 194.—MYDRIASIS.

Paralytic mydriasis may result from intracranial pressure, from the toxins of diseases like syphilis, diphtheria, etc., and from pressure on the ciliary nerves. If the sphincter is only paretic, and not entirely paralyzed, it may be possible to slightly dilate the pupil by mydriatics or contract it by myotics.

Spastic mydriasis, also called spasmodic or irritation mydriasis, occurs in conditions causing reflex irritation of the cervical sympathetic or of the ciliospinal centers situated in the lower cervical or upper dorsal portions of the spinal cord. It may be unilateral or bilateral. As a rule, the pupil is moderately dilated, responds sluggishly to light and convergence, but is not influenced by sensory stimuli, and little if any by mydriatics or myotics. We find it in spinal meningitis in the early stages of all inflammations of the spinal cord, at the origin or along the course of the third nerve, in the general paralysis of the insane, epilepsy, eclampsia, acute mania, melancholia, intestinal irritation, severe anemia (also of the chlorotic type), in conditions causing irritation of the cervical portion of the spinal cord, such as tumors, and as an early sign of locomotor ataxia.

Drug Mydriasis.—This is produced by the instillation into the eye of solutions of atropin, scopolamin, duboisin, daturin, homatropin, euphthalmin, and cocain. Atropin produces dilatation by paralyzing the pupillary branches of the third nerve in the iris, by stimulating the pupillary branches of the sympathetic nerve fibers, and possibly by a direct action on the muscle fiber of the iris itself. Cocain, on the other hand, appears to dilate the

pupil by stimulating the peripheral endings of the sympathetic nerves in the iris. According to Koller, cocain mydriasis is caused by a constriction of the blood-vessels of the iris, the muscle fibers being unaffected. The former view, however, is the one usually accepted by ophthalmologists. In the case of cocain mydriasis there is no paralysis of accommodation, as in the case of atropin and similar drugs.

Contraction of the pupil, or myosis, may be divided into irritation myosis, due to an irritation of the pupil-contracting center or nerve fibers, and paralytic myosis, due to a paralysis of the pupil-dilating center. Both causes may coexist.

FIG. 195.—MYOSIS.

Irritation myosis may occur early in inflammations of the brain and meninges, early in cerebral apoplexy, in pontine hemorrhage, at the onset of a hysterical or epileptic paroxysm, under prolonged accommodation in certain occupations, such as those of engravers, jewelers, etc., and in tobacco amblyopia. In this form of myosis atropin will dilate the pupil, while eserin or pilocarpin will still further contract it.

Paralytic myosis may be due to lesions in the cord above the dorsal vertebræ, and is an important symptom in locomotor ataxia. It is also found in some varieties of bulbar palsy and in paralysis of the cervical sympathetic due to traumatism or to pressure of an aneurysm.

Drug Myosis.—The principal myotics are eserin physiostigmin) and pilocarpin. The latter drug causes myosis by stimulating the peripheral ends of the oculomotor nerve in the iris. Eserin stimulates the peripheral ends of that branch of the third nerve supplying the iris sphincter.

Reactions of the Pupil.—These may be external in origin, as in the reaction to light, accommodation, convergence, etc.; or internal in origin when due to fright, pain, emotion, and other disturbances of the sympathetic system. Their signifi-

cance varies according as the cause is physiological or pathological.

The Direct Light Reflex.—The pupil contracts in the presence of light and dilates in its absence except in sleep.

Accommodation and Convergence.—Accommodative effort is attended by contraction of the pupil, as is also convergence, as when the patient is required to look at a distance and then quickly direct his gaze at a near object, such as the point of a pencil held before him. These usually occur simultaneously; myosis may take place with accommodation alone, but not with convergence. For instance, in atropin mydriasis, the power of convergence is intact, but the myosis is prevented by the atropin.

The **sensory** or so-called **skin reflex** is the reaction which occurs when the skin of the neck is pinched or irritated by the faradic brush.

Consensual reaction or **indirect light** reflex is the reaction that takes place in an eye excluded from the light simultaneously with the eye exposed. It may be observed by shading one eye and having the other directed toward a bright light; contraction should take place at the same time in both pupils in the absence of any diseased conditions. This phenomenon is explained by the single center in the brain which governs the pupillary reactions.

Hippus is the term employed to designate a chronic spasm of the iris, as is seen in hysteria, neurasthenia, epilepsy, meningitis, and various spinal diseases, but is also used to describe the unsteady or oscillatory movement of the pupil in changing from dilatation to contraction or rest. A dilated pupil when exposed to influences that induce contraction becomes contracted at once, but dilates again to be followed by a subsequent contraction, and so on until a condition of equilibrium is established. It probably arises from the diminution in the light supply by the contraction which induces the subsequent dilatation. Oscillation of the pupil also occurs synchronously with the heart-beat and respiratory movements.

Wernicke's hemiopic pupillary inaction consists in contraction of the pupil by exposure of the blind portions of the retina to light if the cerebral lesion is posterior to the pupillary centers—i. e., in the cuneus or optic radiations—and an entire absence of

reaction if the lesion is anterior to those centers—i. e., in the optic nerve, chiasm, or tract.

The **Argyll-Robertson pupil** is one in which the reaction to light is lost, but the reaction for accommodation and convergence is preserved. It is a common symptom in locomotor ataxia and in some stages of paresis.

Anisocoria is the technical term of the inequality of the pupils, a condition rarely present in health. It is a symptom of insanity, paresis, locomotor ataxia, and similar grave affections. Unilateral blindness, anisometropia, dental disease, and aneurysm may also induce it. It often occurs in epilepsy between the paroxysms.

Orbicularis pupillary reaction, also known as the Gifford-Galassi reflex, and the Westphal-Piltz reaction, consists in the prompt contraction of the pupil that follows an attempt to forcibly close the lids. It is also explained by the intermingling of the nerves of the [illegible] facial and trifacial nerve and is reflex in character.

Paradoxical reactions [illegible] observed in hysteria and meningitis [illegible] exposure to light [illegible] See General Paralysis [illegible]

The cerebral cortex reflex [illegible] **Haab's reflex** consists [illegible]

THE OCULAR MANIFESTATIONS OF NERVOUS DISEASES

General Considerations [illegible]

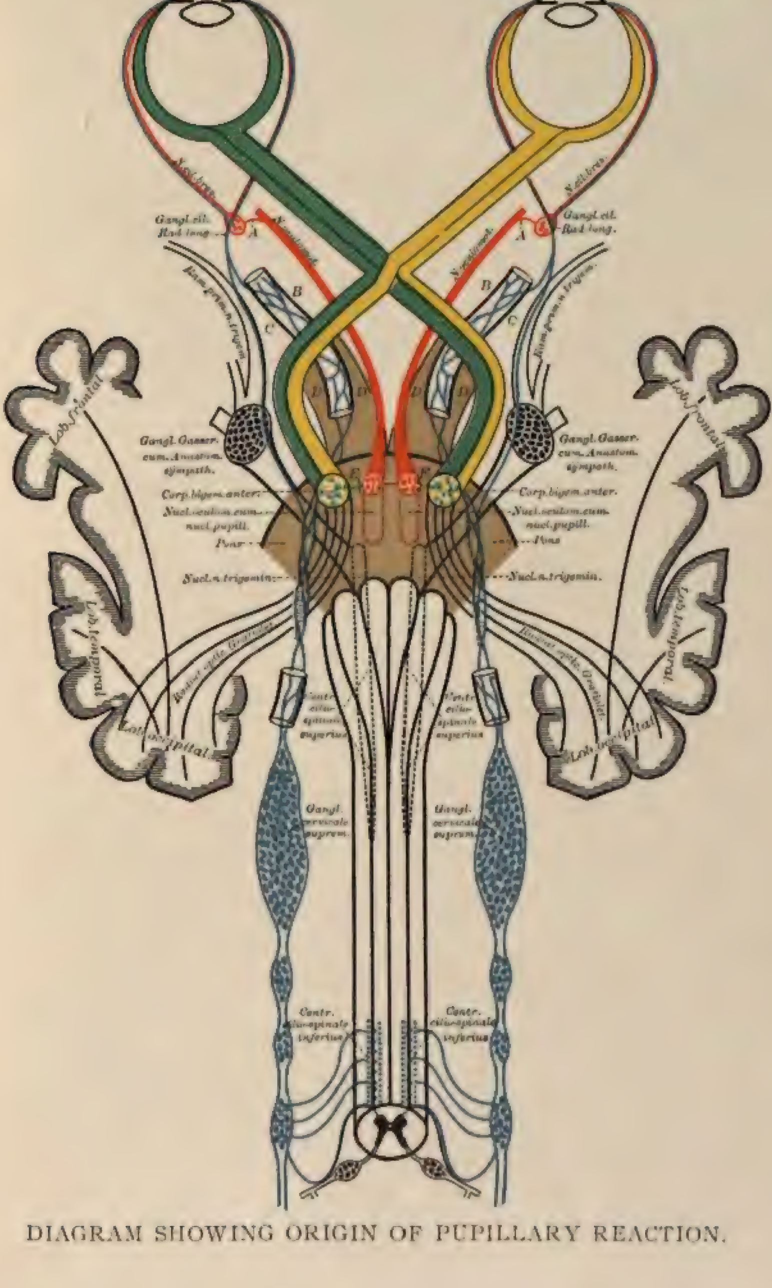


DIAGRAM SHOWING ORIGIN OF PUPILLARY REACTION.

ophthalmoscope in determining diseases situated in parts of the body other than the eye is of especial importance in affections of the nervous system. The intimate relation of the optic nerve to the brain, both in situation and in function, furnishes us with data which are inaccessible by other methods. A better knowledge of the anatomy and physiology of the visual pathways, the mechanism of pupillary phenomena, the ocular manifestations of focal lesions, the relations of the cranial nerves supplying the eye and its appendages, and the proximity to the eye of the meninges and intracranial circulation—all tend to unite with greater relationship the sciences of ophthalmology and neurology.

It is not within the scope of a practical treatise on ophthalmology to discuss all of the important observations that have been made both by neurologists and ophthalmologists. In order that the student, however, may have a more comprehensive knowledge of the subject, a few of the more important nervous diseases will be described. The timely detection of an optic neuritis, abnormal pupillary phenomena, anomalies of the ocular muscles, beginning optic atrophy, and changes in the visual fields, will often serve to elucidate an otherwise obscure case. It is essential that the student acquaint himself with the use of the ophthalmoscope, as well as the differentiation between the *physiological*, *pathological*, and *congenital* conditions of the eye-ground.

Meningitis.—Inflammation of the dura (pachymeningitis), inflammation of the pia and arachnoid (leptomeningitis), tubercular meningitis, as well as traumatism of these structures, may all give rise to optic neuritis. If the base of the brain is involved and pressure exerted on those cranial nerves supplying the eye and its appendages, various manifestations will arise. Pressure on the third nerve may involve the ocular muscles which it supplies, pressure on the sixth nerve may cause palsy of the external rectus muscle, pressure on the optic tracts or nerves themselves may cause anomalies of vision and of the visual fields, while if the fifth nerve is encroached upon, pain or anesthesia may occur in the areas of its distribution. Strabismus and an interference with the conjugate movements of the eyes frequently occur, though not so frequently when the dura alone is involved.

Tubercular Meningitis.—This is deserving of a special mention. In this variety, on account of the more frequent involvement of the base of the brain, optic neuritis, as well as the muscular palsies, occur more often than in the other varieties of the disease. Miliary tubercles of the choroid are a frequent occurrence, yet they do not occur as often as in general tuberculosis. The retina may be involved as a result of an extension from the choroid.

Brain Tumor.—One of the most important intra-ocular symptoms (*choked disk,* or *papilledema*) occurs, according to Gowers, in at least four fifths of all cases of brain tumor. Many differences still exist as to what causes the changes in the fundus oculi. Many clinical and experimental investigations have been made. Only a few can be discussed within the scope of this work. Notwithstanding the anatomical and clinical researches that have been conducted, there is as yet no unanimity of opinion on the subject.

The Cause of Papilledema.—It was not long after the invention of the ophthalmoscope (1853) that the relation between brain tumor and involvement of the optic nerve was recognized, but the matter was not seriously brought before the profession at large until von Graefe published his theory that the increase of intracranial pressure upon the cavernous sinus interfered with the egress of blood from the superior ophthalmic vein and the central vein of the retina, causing a stasis which incarcerated the nerve head within the nonresisting scleral ring surrounding it. In 1869, however, Sesemenn, after an extensive investigation of the venous circulation of the orbit and adjacent structures, showed that the superior ophthalmic vein anastomoses freely with the anterior facial vein (see chapter on The Anatomy of the Eye). An interference with the venous circulation to the cranium cannot therefore be held directly responsible for a venous stasis in the eye. A further study was subsequently made by Judeich (*Zeitschrift f. Augenheilk.*, vol. iii, p. 739), who showed that there were three additional anastomoses—(1) between the ethmoidal vein and the superior and posterior portions of the nose and its posterior sinuses, (2) with the temporal veins, (3) with the deep facial veins and the pterygoid plexus into the sphenopalatine fossa and thence into the deep veins of the nose,

and finally those of the jaw. Leber (*G. S. Handbuch d. ges. Aug.*, vol. ii, No. 2, second edition) claims with considerable logic that if intra-ocular stasis were the cause, there would follow a participation on the part of the veins of the lid and conjunctiva, neither of which occurs in papilledema.

After Schwalbe had demonstrated that the vaginal space of the optic nerve was a continuation of the meninges, and that the lymph spaces of the two communicated with each other, the theory was advanced by Schmidt-Rimpler that the abnormal intracranial pressure has a mechanical influence upon the intervaginal space of the optic nerve, exerted chiefly at its orbital end, and finally into the lamina cribrosa. At the same time Manz believed that this pressure did not cause an accumulation of fluid into the lamina cribrosa, but that the distention compressed the blood-vessels. In short, the nonresistant lamina cribrosa was pushed forward into the vitreous. This theory has many adherents as well as opponents.

That papilledema is due to inflammatory or toxic causes was advanced by von Leber in 1881. According to this author a toxic material gained access to the cerebrospinal fluid and thence through the intervaginal space into the optic nerve, the stasis and edema being the pathological sequences of the inflammatory processes. This theory has been especially upheld by Deutschmann, Gowers, Lawford, Haab, Elschnig, and others. The last one to lend his support to it has been Walter Thorner. The researches of Bordley and Cushing (sections on Ophthalmology and on Nervous and Mental Diseases, American Medical Association, June 2 to 5, 1908), on the other hand, in their series of magnificent experimental and clinical observations, emphasize the importance of the mechanical factors. Indeed, amid all the controversy on the subject since the invention of the ophthalmoscope, judging from the results of the operations for papilledema that have been performed during recent times, the significance of abnormal intracranial pressure confronts us with great vividness, and in the light of modern investigations has the unqualified support of the author. There are a number of other theories, none of which at the present time have as many adherents as those described.

The relative frequency of choked disk in tumors of various

is frequently enabled to predict the diagnosis from the ocular symptoms.

Pupillary Phenomena.—The pupil is frequently contracted, sometimes to the extent of what is known as a "pin-point pupil" (spinal myosis), but even in this condition it may still react to light and convergence.

The most important pupillary symptom in tabes dorsalis is the **Argyll-Robertson pupil,** the reaction for light being lost and that for convergence and accommodation preserved. The myosis may or may not be present in conjunction with this phenomenon. It is frequently one of the earliest symptoms of the disease, and may occur on one side only. Inequality of the pupils may be present. Mydriasis is a late symptom.

Orbital Muscles.—The orbital muscles are affected in about 30 per cent of the cases. The paresis may affect one to several muscles, causing strabismus, and may be permanent or transient. *Diplopia* occurs as a result of these conditions, and may often be an initial symptom of this affection. The sixth nerve is more commonly involved than the third, and if the branch of the latter which supplies the levator palpebræ is involved, *ptosis* will occur. External ophthalmoplegia may result.

Ocular Ataxy (Swanzy).—This is a twitching of the eyeballs when the patient makes an effort at fixation, but does not occur when the eyes are at rest. It is therefore not to be confounded with the term "nystagmus," which is a constant oscillation of the eyeballs.

Optic-nerve Atrophy.—This symptom occurs in from 20 to 30 per cent of cases. It is more frequent in men than in women. It is usually an early symptom, and frequently the first one. Even after optic atrophy occurs, the other symptoms may be delayed for many years, Charcot having reported a case where the optic atrophy preceded the other symptoms by ten years, and other observers for even longer periods. The disk is of a dead-white color. There are some changes in the retinal vessels, but not until later in the disease, but they are not as greatly involved in this form of atrophy as they are in that consecutive to optic neuritis.

As the atrophy progresses the visual fields become contracted,

and finally in the greater number of cases the loss of central vision continues to complete blindness.

Disseminated Sclerosis.—There are several important ocular symptoms in this disease. Visual disturbances occur in about half of the cases.

Optic-nerve Atrophy.—According to Uhthoff the optic nerves are involved more frequently in multiple sclerosis than in locomotor ataxia, and, with the exception of brain tumor, more frequently than in any other disease of the nervous system. The changes in the disk are the result of a retrobulbar neuritis. To quote from Ward A. Holden, who is of the opinion that "we shall soon come to the belief that a nontoxic retrobulbar neuritis, if not due to a sinusitis or directly to syphilis, diabetes, a neoplasm, or trauma, is, as a rule, a manifestation of multiple sclerosis, although no other symptoms of the disease may be present."

Visual Fields.—The disturbances in the visual fields occurring in this disease are central scotomata, either for color or absolute. The fields may show peripheral alterations or there may be concentric narrowing, leading sometimes to blindness, which, however, rarely remains permanent.

Nystagmus.—This is a common symptom in disseminated sclerosis, occurring, according to Swanzy, in about 50 per cent of the cases, among which are included those oscillations resembling the nystagmus. The intentional nystagmus of this disease is undoubtedly closely associated in its causation to the intention tremor of the extremities.

Extra-ocular Muscles.—One or more of these may be paralyzed, and the conjugate movements may be interfered with. The muscular involvement is usually bilateral and transient in character. Complete ophthalmoplegia is rare.

Functional insanity is attended by varied alterations of the pupil; the ocular symptoms, however, are relatively unimportant, for there are no pupillary changes distinctive of any of the functional psychoses. Operations upon the eye may induce a delirium of greater or less intensity; particularly is this so of iridectomy or lens extraction.

General Paralysis of the Insane.—The chief ocular symptoms in this disease are paralysis of the extra-ocular muscles,

pupillary abnormalities, mind blindness, and occasionally optic-nerve atrophy.

Pupillary Phenomena.—The pupils may be dilated late in the disease, while early they are generally contracted and unequal. As the disease progresses consensual reaction may become lost. The Argyll-Robertson phenomenon may occur at some time during the disease, but if so is of short duration. The loss of light reflex, and what is known as the *paradoxic pupil*, are two important signs. The latter phenomenon, in which the pupil first contracts to light stimulus, then dilates some, contracts, oscillates, and then dilates and remains dilated, notwithstanding the light which is still entering the eye is a premonitory symptom of great significance..

Extra-ocular Muscles.—When these are involved it is usually the third and sixth nerve that are paralyzed.

Other symptoms are optic-nerve atrophy, amblyopia, mind blindness, and hemianopsia.

Hydrocephalus.—The eye symptoms occurring in this affection are essentially those due to intracranial pressure, which are, however, less pronounced in childhood than in the acquired disease of adult life, on account of the decrease in resistance provided by the sutures and fontanels. Choked disk, however, frequently occurs, leading to postneuritic atrophy. Notwithstanding, primary optic atrophy is of frequent occurrence, and, according to Parsons, is much commoner than optic neuritis in the case of very young children.

Epilepsy.—The ocular manifestations of this disease are rather symptomatic of the paroxysms than of the disease itself. A common subjective symptom is the *visual aura*, more common than any of the auræ associated with the special senses. *Conjugate lateral deviation* of the eyes to the side of the body opposite from that on which the convulsions originated may be a beginning symptom of the fit. The head then follows the ocular rotation, after which the eyes may again turn to the opposite side. The question of simulation or hysteria may arise. In epilepsy the pupil does not react to light, a valuable point in the differential diagnosis from hysteria. The size of the pupil varies during the attack, but rapid alterations in the pupillary diameter after an attack is strongly presumptive of epilepsy.

Inequality of the pupils (anisocoria) sometimes occurs between the attacks.

The appearance of the eye-ground during epileptic paroxysms is not constant. The blood-vessels may be contracted with pallor of the nerve head, or the latter may be hyperemic with dilatation of the veins.

After the attack the visual fields are generally contracted concentrically for form and sometimes for color as well, but without reversal of the colors. Color-blindness may be present. Errors of refraction are believed by some to be capable of inducing epilepsy in those predisposed, and indeed the proportion of cases relieved by ocular treatment is very gratifying.

Lead Encephalopathy.—This condition is often confounded with brain tumor, and, according to Bramwell (quoted by Swanzy), the following statement is significant: "So closely do the two conditions (tumor and lead encephalopathy) in some cases resemble each other, that I never commit myself to a positive diagnosis of intracranial tumor without having previously excluded lead poisoning." Blindness or hemianopsia may occur and be of short duration. The visual fields may be contracted, and yet the eye-ground may be of normal appearance. Optic neuritis often occurs, and it is here that the differential diagnosis from brain tumor must be made. The patient should be carefully examined for the profound anemia which is often present, for the blue-black line of sulphid of lead on the gums, for the various forms of lead palsy, especially wrist drop, the colic, arthralgias, and other symptoms. In some of the cases uremia may be the underlying cause, as postmortem changes are often absent, yet it is recognized that the brunt of the poisoning may be expended on the nervous system alone.

Chorea.—One of the principal symptoms to engage our attention in chorea, and which often precedes the attack itself, is *blepharospasm*. The disease has often been cured by the correction of anomalies of refraction, but the latter are often not the cause of the disease.

Paralysis Agitans.—The *tremor* of the disease may characterize itself along the margin of the upper eyelids, especially when closed. The general rigidity which is often present in other parts of the body may be seen on an attempt to open the lids.

Amaurotic family idiocy is characterized by a distinct lack of mental development, by a progressive weakness of all the muscles of the body, and by a diminution of vision terminating in absolute blindness. It occurs chiefly in Jewish children. The eye-ground reveals a dark cherry-red spot in the region of the macula lutea, and later optic-nerve atrophy; in some cases nystagmus, strabismus, and hyperacusis (abnormal acuity of hearing) are added to the above. (See Diseases of the Retina.)

Myelitis.—Optic neuritis is rare in this affection, and in the majority of instances precedes the myelitis by a brief interval. The disease is generally bilateral and the diminution of vision rapid. If the cervical cord be involved there may be contraction of the pupil, narrowing of the palpebral fissure, and enophthalmos, owing to impairment of the function of the cervical sympathetic.

Syringomyelia.—Ocular symptoms are uncommon, the most frequent being optic neuritis, ocular muscle palsies, and pupillary changes. There is a frequent complicating internal hydrocephalus which may have etiological bearing upon the eye symptoms. Nystagmoid movements are more common than true nystagmus, being elicited by causing lateral deviation.

Injuries to the Spinal Cord.—If there be fracture, dislocation of vertebræ, or compression by aneurysm or tumor, there may be optic neuritis, particularly if the lesion be above the second dorsal segment. If the cervical sympathetic system be involved there will be dilatation of the pupil, increased width of the palpebral angle, and slight exophthalmos if due to irritation, while paralysis produces a small pupil narrowing of the angle and slight enophthalmos. A number of instances of injury of the upper cervical cord have shown the typical Argyll-Robertson pupillary phenomena.

Tumors of the Cord.—If intracranial involvement occurs, papillitis and optic-nerve atrophy may arise.

Friedreich's Disease.—There is a complete absence of ocular abnormalities, as was emphasized by Friedreich himself, with the exception of one symptom termed pseudo or atactic nystagmus. It consists of irregular twitching when the eyes are fixed on a moving object in the horizontal direction. They are mo-

Hysterical amblyopia includes, besides a subnormal acuity of vision, disturbed light and color perception, contracted visual fields and alterations of accommodation. The contraction of the visual fields will be found to be concentric or tubular; this can best be demonstrated by moving the point of fixation and taking the fields when the fixation distance is 2, 3, or 5 meters, when the width of field will be found to be the same throughout. Binswanger lays stress upon the physical condition and its effect upon the visual fields at the time of the examination. The *inversion of the color fields*, or dyschromatopsia, is shown to be more characteristic of the disease than the mere limitation of color perception. The red field is the last affected, and equals or may exceed the boundaries of the blue field. Achromatopsia, or loss of the violet and green color perception, has been frequently noted and is likely to be accompanied by cutaneous anesthesia. These subjects are usually not inconvenienced by the extreme contraction of their visual fields, as are patients with organic retinal disease.

Hysterical spasm of accommodation may be unilateral or bilateral, partial or total. It is similar to that produced by eserin, causing an approximation of the far and near point of vision as a result depending upon whether these two points coincide; there will be defective distant vision; impairment of accommodation at the near point; as a result the patient can see only at a fixed point. Monocular diplopia, polyopia, and occasionally micropsia and megalopsia are observed, the result of contracture of the ciliary muscle. In hysterical cycloplegia the pupils are usually normal, although cases showing mydriasis have been reported. Asthenopia occurring in this disease is accompanied by photophobia, lacrymation, blepharospasm, and neuralgic pains in the region of the eye more fully detailed under retinal hyperesthesia. The pupillary phenomena are myosis or mydriasis, either spasmodic or paralytic, and preserved but sluggish reactions to either light or accommodation. The state of the pupils cannot be relied upon in the differential diagnosis between hysteria and epilepsy, as they have repeatedly been observed to be dilated and motionless in the former, as is always the case in the latter disease. The paradoxical pupillary reaction or a dilatation of the pupil when a bright light

is thrown upon the eye is not uncommonly a manifestation of hysteria.

Paralysis and spasm of the levator, false paralysis of the upper lid due to spasm of the orbicularis muscle which constitutes the so-called eyebrow sign, clonic and more frequently tonic blepharospasm, are observed. Epiphora, nystagmus of the mixed type, insufficiencies and paralysis of convergence and divergence, spasmodic conjugate deviation and palsies of individual ocular muscles, are less frequently present.

Neurasthenia.—The ocular changes of this disease do not constitute a distinctive symptomatology. Defective or painful vision, sensations usually described as neurasthenic asthenopia, are met with in both children and adults; astigmatism and muscle imbalance are the most frequent causative factors. Anomalies of the pupils or muscular movements are not frequent. Rosenbach's sign, or an inability to close the eyes, associated with marked fibrillary twitching of the orbicularis muscle when the patient is standing with the heels together, is often found. A shifting of the visual field may be noted during the perimetric examination. There is an ocular fatigue in this affection which is responsible for the presence of fatigue, scotomata, and anomalies of the visual fields. There is usually not the disturbance of the color sense which we find in hysteria.

Migraine.—Often divided into "ophthalmic" and "ophthalmoplegic" forms. The visual symptoms of the ophthalmic form are first amblyopia, or a simple blurring of the visual field is perhaps the commonest. This passes next into the stage of scintillations; these consist of waving or vibrating lines of light extending across the visual field. They may be confined to the edges of darkened areas forming scintillating scotomata, the areas assuming a zigzag shape giving the so-called "fortification lines." They are seen with either closed or open eyes, and various colors may be intermingled. Scotomata of ten to twenty minutes' duration, usually affecting both eyes, are frequent. Visual hallucinations have been met with by a few observers. Woodruff believes migraine due to lid pressure accentuated by bright sunshine in the tropics.

The ophthalmoplegic or motor type of the disease is characterized by a paralysis of a number of the ocular muscles. This

occurs as a sequel of the attack, the muscles supplied by the third nerve being most frequently affected; more rarely those supplied by the fourth or the sixth nerve. The attack is characterized by a *period of pain*, often centered about the eye; as the pain and vomiting disappear the *period of paralysis* asserts itself. The palsy, usually of the third nerve, involves all the branches, and the muscles are not weakened but completely paralyzed. The duration may vary from a few weeks to a few months. After repeated attacks of this form the paralysis tends to become more and more persistent, and in time may become permanent. The oculomotor palsy due to syphilis and brain tumors must be differentiated from the above.

Headache.—When ocular conditions cause eye-strain, other things being equal, the neurotic individual is most likely to suffer from headache and associated phenomena. Experience has shown in other groups of patients suffering from headache that there may be no relation between the existing ocular defects and the pain in the head, since correction of the abnormalities fails to afford relief—i. e., some cases of migraine. Or there may be amelioration of the ocular symptoms, as blepharitis and recurring styes, without any appreciable effect upon the headache. Therefore the general condition as to health, temperament, and the necessity for the constant use of the eyes, must be considered in treating headache dependent upon ocular defects. A journey by rail, after shopping, an evening at the opera, or prolonged use of the eyes at near work, are all potent causes in the production of ocular headaches. Closely allied with the above forms are those patients who claim to suffer from what they call nervous headaches; as a rule, these are unaccompanied by nausea, but display muscular spasms and hysterical crisis. Here not only is there astigmatism with hypermetropia, but frequently ocular muscle imbalance. Patients suffering from nephritis, gout, and influenza have been treated most actively for headache supposedly due to the above diseases, only to find that correction of a moderate astigmatism has rapidly banished their pain. The facial twitchings of school children with nervous irritability, headache, and capricious appetite, form a large class in which the correction of refraction error is almost magical in its effect. The aged not infrequently suffer from headache, insomnia, and neuralgia,

in which the exciting cause is chororetinitis, long-standing blepharitis, or incipient cataract wherein suitable local treatment is curative.

While, unfortunately, the mechanism of headache is but little understood, that of eye-strain is quite clear, for with astigmatism, heteronymous refraction, muscle imbalance, the struggle and difficulties necessary to the maintenance of clear binocular vision, are enormous.

CHAPTER XXII

REFRACTION

ELEMENTARY OPTICAL PRINCIPLES

Optics is that branch of physical science which treats of light and vision, the organs of sight, chromatics, and the various phenomena connected with sight.

Light is that form of radiant energy which acts on the retina and renders visible the objects from which it proceeds. It is the result of innumerable undulations or little waves transmitted with inconceivable velocity through a highly elastic medium of excessive tenuity known as ether.

The chief phenomena of light are *reflection, refraction, dispersion, interference,* and *polarization.* From a luminous body light-waves are emitted which proceed in a straight line in every plane and direction with a velocity of about 186,427 miles per second. These lines of direction are called *rays.* The amount of divergence of these rays depends upon the distance from the luminous source, being greatest the farther the source of light. At a distance of 6 meters the divergence is so slight that for practical purposes rays of light at that distance from their source may be said to be parallel.

In passing from a rare to a dense medium the rays may undergo *absorption, reflection,* or *refraction,* depending upon the density of the medium.

Absorption takes place when part or all of the primary colors of the spectrum are taken up. Substances said to be black in color are those in which all the primary colors have been absorbed. Opaque and colored substances absorb only a portion of the rays, the rest being reflected, refracted, or both.

Reflection consists in returning or throwing off of rays from the surface upon which they impinge into the medium from which

they came. The ray of light striking upon the polished surface is called the *incidental* ray; that which is returned is known as the *reflected* ray.

The angle formed by the incident ray and a line drawn perpendicular to the plane surface is called the *angle of incidence,*

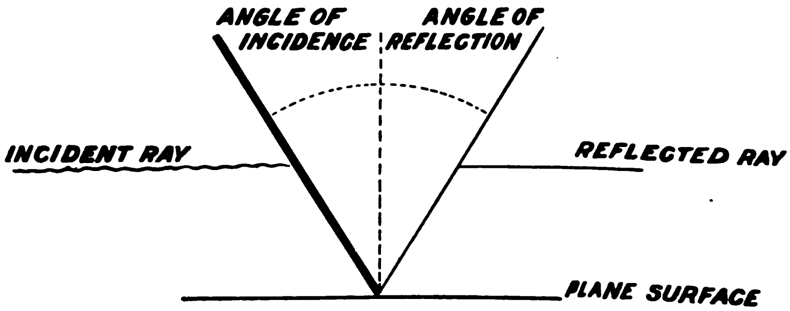


FIG. 196.

and is equal to the angle formed by the reflected ray and the perpendicular, or *angle of reflection.* The incident and reflected

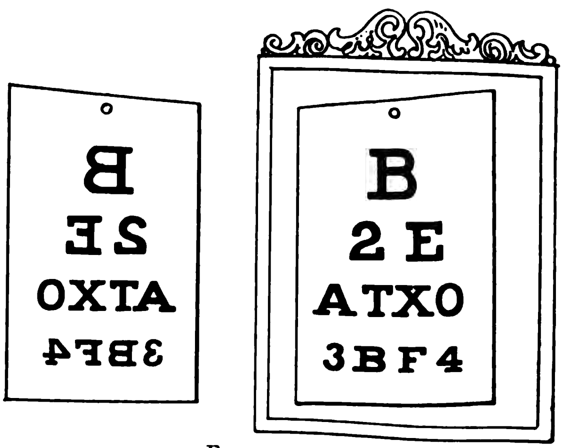


FIG. 197.

rays are contained in the same normal place with the perpendicular to the reflecting surface.

Reflection by a plane surface or mirror causes the rays to be returned unaltered in direction (parallel remaining parallel, divergent continuing as divergent, etc.) and gives rise to an erect im-

age. The object appears just as far back in the mirror as it is placed in front of it and undergoes lateral inversion. This fact is made use of in the following manner: Cards made with test letters reversed are employed for taking vision in small rooms, and by the aid of a mirror the distance from the patient to the test card can be doubled. For practical purposes the slight change due to inversion may be ignored. Lateral inversion may be easily demonstrated by tilting the mirror, the object appearing to move in the same direction as that in which the mirror is tilted.

The image formed at a distance behind the reflecting surface by the prolongation of the rays is the *virtual image*; that formed by the reflected rays is the *real image*.

A **concave surface** reflects rays in a manner similar to that of a number of plane surfaces inclined toward one another. Paral-

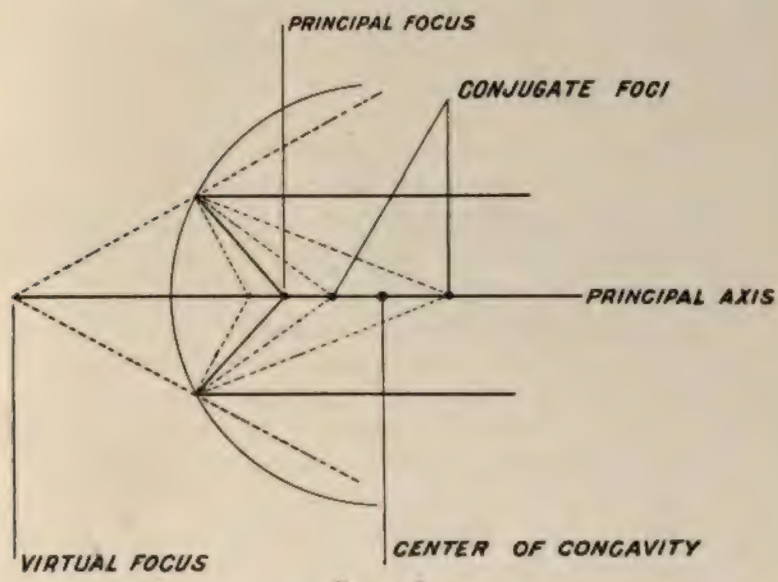


FIG. 198.

lel rays are caused to converge and meet at a point in front of the concave surface called the *principal focus*. A line drawn from the center of concavity passing through the principal focus to the center of curvature is known as the *principal axis*. The

through which they pass. A ray of light striking a plane surface perpendicularly passes through the medium unaltered in its direction, being unaffected by the density of the medium. An oblique ray passing from a rare to a denser medium is refracted or bent toward a line perpendicular to the surface of the dense substance. Upon emerging from the dense medium the ray continues its course parallel to the original course it took before being refracted.

The **index of refraction** is the term applied in describing the comparative refractive power of different bodies, and may be ob-

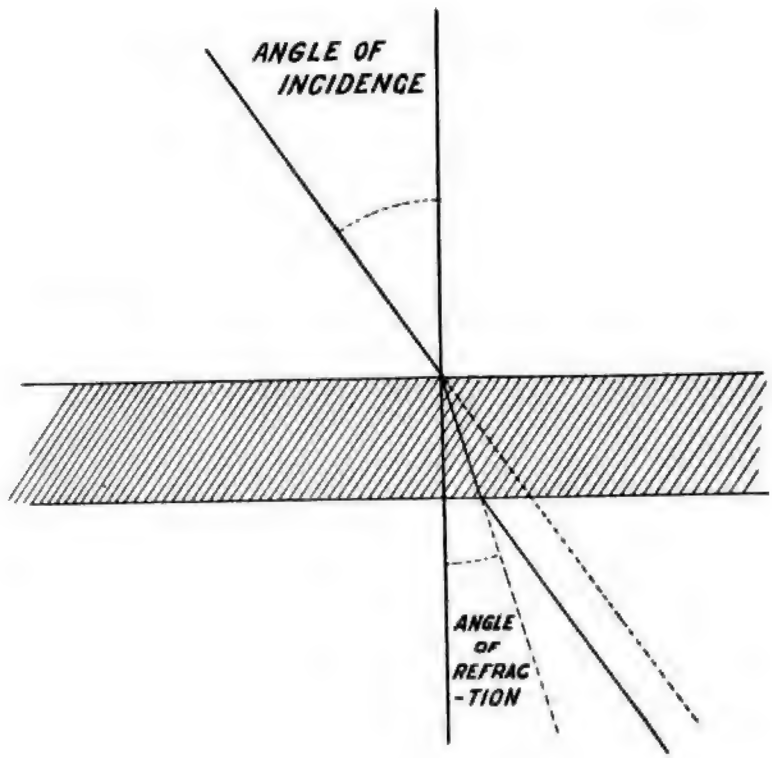


FIG. 199.

tained by dividing the *sine* of the angle of incidence by the *sine* of the angle of refraction, owing to the fixed ratio which exists between them. The following table shows the range of the index of refraction in ordinary substances:

toward the apex, and this fact is made use of in disorders of the ocular muscles. A prism has no focusing power and cannot form images. Parallel rays pass through unchanged in their relation to each other, as those which were parallel before refraction by a prism are parallel thereafter.

The strength of prisms may be expressed in degrees, in centrads, or in prism-diopters. In the first, the value of the prism corresponds to the degree of the refracting angle; in the second, the centrad corresponds to the deviation, the arc of which is $\frac{1}{100}$ of the radius; in the third, the unit is the prism-diopter, which will deflect a ray of light 1 cm. for each diopter of distance, the deviation being measured on the tangent. The difference between the systems in the lower numbers of prisms is so slight that for practical purposes it may be disregarded.

Neutralization of prisms is often necessary to determine the degree of prism contained in ordinary spectacle lenses. It essentially consists in finding the axis in which they decenter the lens under examination. This may be easily performed by holding the prism, with the base toward the right, at 1 meter distance, over a series of numbered parallel lines separated by an interval of 1 cm., and noting the amount of displacement of the first line. (Fig. 201.)

Prisms are used to overcome the effects of paralysis and insufficiency of the ocular muscles, as a test for disturbance of muscle equilibrium, in ocular gymnastics, and to determine the presence or absence of monocular blindness in malingerers.

Lenses.—A lens is a piece of glass or other transparent substance, one surface of which at least must be curved. Lenses may be spherical, cylindrical, or a combination of both properties on the two surfaces may be produced.

Spherical lenses are those in which the curved surfaces are segments of spheres. They refract rays of light equally in all meridians, and are of two kinds, convex and concave.

A **convex spherical** lens may be considered as being made up of two prisms, the bases of which are placed in apposition, and hence has the power of converging parallel rays or bringing them to a focus. A convex lens may also be designated as a converging, magnifying, positive, or plus lens. It may be made in three forms: *Plano-convex,* in which one surface is plane and the other

The *focal length* of a lens is the distance from the optical center to the principal focus.

The *principal focus* or shortest focus is a point on the axial ray or prolongation of the principal axis where parallel rays meet.

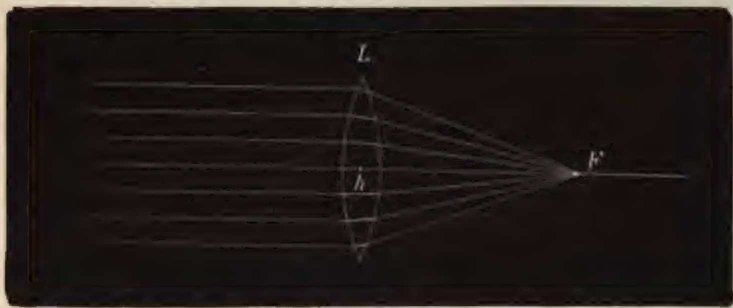


FIG. 202.—UNION OF PARALLEL RAYS EFFECTED BY A CONVEX LENS.

This point is located on the principal axis, and is always at a fixed distance.

Conjugate Foci.—The point from which divergent rays of light proceed before passing through a convex lens and the point at which they are focused after passing through, are called conjugate foci.

Images formed by lenses result from a collection of foci, and may be real or virtual. A real image is formed by the actual

FIG. 203.—DISPERSION OF PARALLEL RAYS BY A CONCAVE LENS.

meeting of the rays, and can be projected upon a screen. A virtual image results from prolongation backward of diverging rays until they meet. Such an image can be seen only by looking through the lens.

has instead a line of foci parallel to its axis. Rays of light passing through cylinders are refracted in the same manner as in passing through other concave or convex media, but only in one meridian, that at right angles to the axis. *Cylinders are used to correct astigmatism*, and may be combined with concave or convex spherical lenses; such combinations are known as *sphero-cylinders*. If one surface has no curve whatever (plano), and the other a cylindrical curve, it is known as a plain or simple cylinder.

Cross Cylinders.—When two cylinders of different denominations with opposite axes are combined—i. e., if one surface of a lens represents a cylinder at a certain axis, while the opposite surface also has a cylinder with its axis at right angles to the other—the combination is known as *cross cylinders*. If the two cylinders are of the same strength they equal a sphere of the same value; if not, they can be transposed into a compound lens, as will be hereafter shown. In addition to the two cylinders at right angles, similar combinations can be written by combining a convex sphere with a concave cylinder, the cylinder being stronger than the sphere, or a concave sphere with a convex cylinder, the latter being likewise the stronger.

FIG. 205.—THE CONVEX CYLINDRICAL LENS CONSIDERED AS A SEGMENT OF A CYLINDER.

Lens Values, Their Combination and Transposition.—The value of every lens in diopters is equal to the combined value of its two surfaces in algebraic notation. Thus, if in a convex lens the spherical curve represents a power of plus 2 diopters, and the opposite surface has a concave curve representing a power of minus 2 diopters, then the value of the algebraic combination is zero, and as the one surface neutralizes the other, the lens is equal to a piece of plane glass. But if both surfaces should represent a power of either plus 2 or minus 2 diopters, then the lenses would each represent a total value of plus 4 or minus 4 diopters respectively. Again, if one surface represented a value

of plus 4 diopters, and the other surface a value of minus 3 diopters, then the value of that lens would be plus 1 diopter, and *vice versa.*

In the case where one surface is spherical, and the opposite one is cylindrical, then the dissimilar quantities cannot be added, just the same as in algebra x and y cannot be added without the interposition of a sign. In this case each is expressed by its own name prefixed by its own value, with the interposition of the combination mark, the whole being called a *compound lens.*

The following rules may be applied when it is desired to transpose compound or cylindrical lenses from one form to an equivalent form:

1. *To obtain the sphere of the desired lens add algebraically the values of the old sphere and cylinder.*

2. *To obtain the cylinder of the desired lens, reverse the sign of the old cylinder, leave its value unchanged, and change its axis ninety degrees.*

For instance, if it is desired to transpose the following:

+ 2 spher. ○ + 2 cyl. ax. 90°,

The result would be:

+ 4 spher. ○ − 2 cyl. ax. 180°.

Or, if it is desired to transpose the following:

+ .75 cyl. ax. 135°,

The result would be:

+ .75 spher. ○ − .75 cyl. ax. 45°, because the "plane" surface is used for the calculation of the new sphere.

If the following is to be transposed:

+ 1.75 spher. ○ − 1.75 cyl. ax. 10°,

The result will be as follows:

+ 1.75 cyl. ax. 100°, reducing one surface of the lens to a "plane" surface.

In the case of cross cylinders the following rules apply:

1. *The value of the required sphere is obtained by taking the value of one of the cylinders of the cross cylinder.*

2. *Deduct algebraically the value thus obtained from the value of the other cylinder of the cross cylinder in order to obtain the cylinder for the compound lens. The axis is that of the cylinder last used.* For example, if it is desired to transpose the following combination to an equivalent compound lens:

+ 1 cyl. ax. 30 = + 2 cyl. ax. 120°,

This combination when transposed will read:

+ 1 spher. = − 2 cyl. ax. 120°.

Toric lenses consist of a deep inner curve, the lens being ground so that the other surface has the optical effects of a spherocylinder, or that of two cylinders of different values at right angles to each other. They are often used to enlarge the visual fields, especially in astigmatism.

Numeration of Lenses.—This is based upon the refractive power or strength of the lens which is indicated by its principal focal distance. The strength of a lens varies inversely as its focal distance. It is most commonly expressed in the metric system, in which a lens having a focal distance of 1 meter is taken as a unit. This unit is known as the DIOPTER. Lenses of greater or less strength than this are expressed in whole numbers or decimals. A lens of 2 diopters has a focal length of ½ meter, while a lens of 0.50 diopters has a focal length of 2 meters, as shown in the table on page 606.

Neutralization of Lenses.—A spherical lens if held a short distance before the eye and moved in every direction will cause movement of the objects seen through the lens, with the lens if the latter be concave, and against the lens if it be convex. That lens of opposite power held before the lens under examination, which causes cessation of movement, indicates the strength of the lens. Concave and convex lenses of the same focal distance when held together neutralize each other and produce no movement of objects seen through them, because the minus lens will diverge the rays of light to exactly the same extent as the plus lens will converge them.

In cylindrical lenses the meridian in which there is no movement indicates the axis. The cylinder of opposite power which, placed at the same axis, causes cessation of the movement in the first cylinder, indicates its strength.

A lens measure may be employed to determine the strength of a lens, but requires taking of the curvature of both surfaces of the lens.

The *optical center* of a lens should correspond to the geometrical center, but often this is not the case, owing to the intentional decentering of the lens. The center may be easily ascertained by

	Number of Lens in Diopters	Focal Distance in Millimeters	Focal Distance in Inches	Nearest Corresponding Lens in Old System
	0.12	8000	314.96	......
	0.25	4000	157.48	144
	0.37	2666	104.99	96
	0.50	2000	78.74	72
Interval of 0.12 D...	0.62	1600	62.99	60
	0.75	1333	52.5	48
	0.87	143	44.99	42
	1.00	000	39.37	40
	1.12	888	34.99	36
	1.25	800	31.5	30
	1.50	666	26.22	26
	1.75	571	22.48	22
	2.00	500	19.69	20
	2.25	444	17.48	18
	2.50	400	15.75	16
	2.75	363	14.31	15 or 14
	3.00	333	13.12	13
Interval of 0.25 D...	3.25	308	12.11	12
	3.50	285	11.25	11
	3.75	266	10.49	......
	4.00	250	9.84	10
	4.25	235	9.26	9
	4.50	222	8.74	......
	4.75	210	8.29	......
	5.00	200	7.87	8
	5.50	182	7.16	7
	6.00	166	6.54	......
Interval of 0.50 D...	6.50	154	6.06	6
	7.00	143	5.63	......
	7.50	133	5.25	......
	8.00	125	4.92	5
	9.00	111	4.37	4.5
	10.00	100	3.94	4
	11.00	91	3.58	3.50
	12	83	3.27	3.25
Interval of 1 D......	13	77	3.03	3
	14	71	2.8	2.75
	15	66	2.64	......
	16	62	2.44	2.5
	17	59	2.32	......
	18	55	2.17	2.25
Interval of 2 D......	20	50	1.97	2
	22	45	1.79	1.75

In the old system the lenses are ground with a radius curvature in Paris inches. The focal length is almost exactly the same number of English inches as the radius of curvature is of French inches.

looking through the lens at two lines crossed at right angles. When the lens is so placed that the portions of the lines outside of the lens are directly continuous with those seen through the glass, the point where the lines cross will indicate the optical center.

ABBREVIATIONS USED IN OPHTHALMOLOGY

Am.	Ametropia.
As.	Astigmatism.
H.a. or H.a.s.	Hyperopic astigmatism.
M.a. or M.a.s.	Myopic astigmatism.
C. or Cyl.	Cylinder.
D.	Diopter.
E. or Em.	Emmetropia.
H.	Hyperopia.
M.	Myopia.
M.A.	Meter.
O.D.	Oculus dexter (right eye).
O.S.	Oculus sinister (left eye).
O.U. or O_2.	Oculi utrique (both eyes).
P.p.	Punctum proximum (near point).
P.r.	Punctum remotum (far point).
Pr. or P.	Presbyopia.
S. or Sph.	Spherical lens.
T.	Tension.
V.	Vision.
+	Plus or convex.
—	Minus or concave.
=	Equal to.
$\subset$	Combined with.

PHYSIOLOGICAL OPTICS

Vision results from the interpretation in the brain of impulses produced by images thrown upon the retina. These images, when perfectly formed, are inverted and smaller than the objects from which they came, and stimulate the rods and cones of the retina, particularly in the macular region. The eye resembles in some respects a photographic camera, the small images of objects being thrown upon the retina in an inverted position. The stimulus given the rods and cones by this image is transmitted to the visual centers of the brain, and there by its action upon the ganglion cells of the cortex enables the brain to interpret the retinal impressions. Imperfect formation of the images by

the refracting media results in failure to properly stimulate the rods and cones, and blurring of vision is the consequence.

For purposes of study it is necessary to project a schematic eye which, when in a state of rest, will cause parallel rays entering it to be focused on the macula. Such an eye would have an antero-posterior diameter of 23 mm., and its nodal point or optical center would be 7 mm. back of the anterior surface of the cornea and 15 mm. from the fovea.

Curvatures of a schematic eye:

Anterior surface of the cornea........	7.8 mm.
Posterior surface of the cornea.......	6.0 "
Anterior surface of the lens..........	10.0 "
Posterior surface of the lens.........	6.0 "

Indices of refraction of the transparent portions of a schematic eye:

Cornea	1.377
Aqueous	1.337
Lens	1.438
Vitreous	1.337

A schematic eye is a compound dioptric system having three refracting surfaces, the anterior surface of the cornea and the

FIG. 206.—REDUCED (SCHEMATIC) EYE OF DONDERS.

anterior and posterior surfaces of the lens, and three refracting media, the aqueous, the lens substance, and the vitreous. These

surfaces and media are all centered on a line called the *optic axis*, which connects the center of the cornea, the nodal point, and the posterior principal focus on the retina.

Although the refracting apparatus of a schematic eye forms a compound dioptric system, this compound system may be substituted by a single system composed of *six cardinal points* and *six planes*, the latter being situated at the cardinal points perpendicular to the optical axis. The cardinal points are: 2 principal points, 2 nodal points, and 2 principal foci. The planes bear corresponding names.

The location of the cardinal points is as follows:

First principal point, 1.8 mm. behind the anterior surface of the cornea.

Second principal point, 2.1 mm. behind the anterior surface of the cornea.

First nodal point, 7.1 mm. behind the anterior surface of the cornea.

Second nodal point, 7.4 mm. behind the anterior surface of the cornea.

Anterior principal focus, 14 mm. in front of the cornea.

Posterior principal focus, 24 mm. behind the anterior surface of the cornea.

The *principal points* are placed close together in the anterior chamber, and the relation between them is such that when an in-

FIG. 207.—BEHAVIOR OF THE VISUAL ANGLE WHEN OBJECTS VARY IN SIZE AND DISTANCE.

cidental ray passes through the first principal point the corresponding emergent ray will pass through the second principal point. The space between these points is so small that for ordinary purposes the points may be considered as one.

The *nodal points* are also placed close together, being so situated near the posterior pole of the lens; they correspond to the optical center, and rays passing through them undergo no alteration.

The *first principal focus* is a point on the axis at which parallel rays from the vitreous meet (about 14 mm. in front of the cornea), while the *second principal focus* is also a point on the axis situated between the macula and optic disk (from 22 mm. to 23 mm. behind the cornea) at which parallel rays meet after being refracted by the dioptric system of the eye.

The *center of rotation* of the eyeball is situated in the vitreous about 10 mm. in front of the retina.

The *visual angle* is the angle which rays of light from the extremities of an object subtend at the nodal point or optical center. The apparent size of an object depends upon the extent of the visual angle. To determine the size of the retinal image it is necessary to multiply the size of the object by the distance of the nodal point from the retina. The product thus obtained is divided by the distance of the object from the nodal point, and the resulting quotient is the size of the retinal image.

The *visual line* is a line that extends from the object to the macula passing through the nodal point.

The *fixation line* joins the object with the center of rotation, and frequently corresponds to the visual line.

The *angle gamma* is the angle formed by the optical axis with the fixation line and varies with the refraction of the eye. In the emmetropic eye it is about 5 degrees; it increases in hyperopia and decreases in myopia.

The *angle alpha* is formed by the long axis of the corneal ellipse and the visual line.

The term *refraction* is also applied to express the optical condition of the eye in a state of rest.

Emmetropia is a condition of refraction of the eye in which parallel rays from a distance of 6 meters are focused on the macula when the eye is in a state of rest. This condition is present in the schematic eye already described.

Ametropia is a more frequent condition of refraction in human eyes, and is due to the formation of images elsewhere than on the retina. It includes *hyperopia, myopia,* and *astigmatism.*

Hyperopia is a condition in which the rays are focused behind the retina, while in *myopia* the focus occurs in front of the retina. In *astigmatism* the rays are differently refracted in the various meridians, giving rise to a blurred image.

Accommodation.—The arrangement of the dioptric mechanism of a schematic eye provides only for the focusing of parallel rays of light from a distance of 6 or more meters; any object placed at a closer range would be focused behind the retina, giving rise to a blurred image unless the visual angle was of the

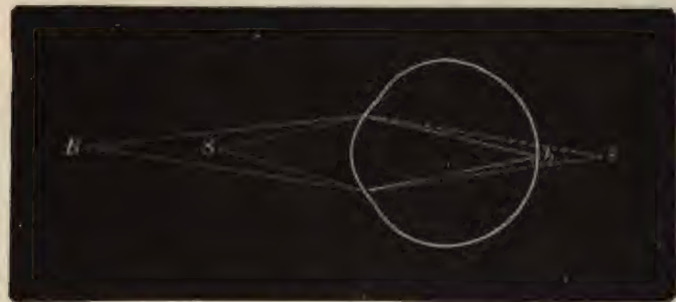


FIG. 208.

The eye being focused for a certain distance, *B*, rays emanating from a nearer point, *S*, form a diffusion circle upon the retina.

same degree as that of some standard object at 6 meters' distance. In the human eye provision is made for altering the refraction, so that objects at close range as well as those at a distance may be clearly perceived. The phenomena attending this alteration constitute accommodation.

In any optical apparatus, such as a camera, this change of focus is accomplished by increasing the distance from the lens to the part corresponding to the retina, but in the eye it is brought about by an additional refractive power in the lens. This may easily be proved by the images which a lighted candle throws upon the anterior surface of the cornea, upon the anterior capsule of the lens, and upon the posterior capsule of the lens. During accommodation the image upon the anterior capsule of the lens diminishes in size and approaches that upon the anterior surface of the cornea.

Accommodation results from contraction of the ciliary muscle, which is attended by relaxation of the suspensory ligament

of the lens. Following this relaxation the lens bulges forward by reason of the elasticity of its fibers. As age advances, the lens loses its elasticity and the function of accommodation is diminished to a corresponding degree. The volume of the lens is not increased during accommodation, the antero-posterior diameter

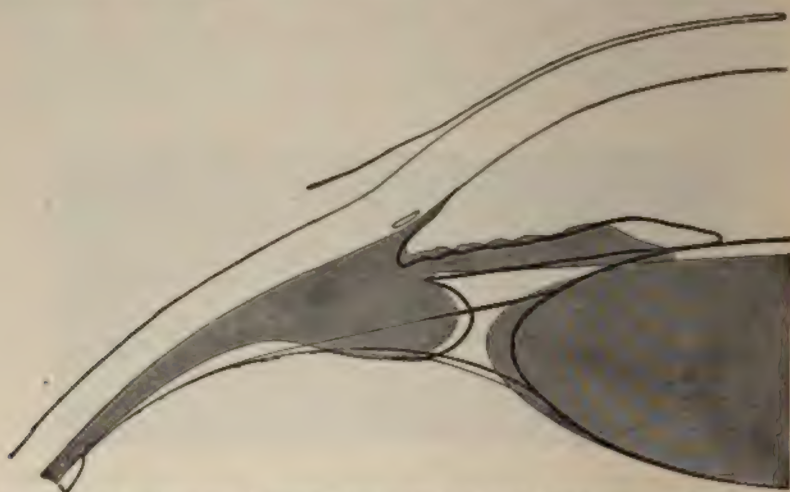


FIG. 209.—SCHEMATIC REPRESENTATION OF THE PROCESS OF ACCOMMODATION.

The relation of the parts when the accommodation is at rest is designated by the shaded portions, and the relation when there is an effort of accommodation, by the black line. The latter shows the ciliary processes and also the equator of the lens pushed toward the axis of the eye. Both surfaces of the lens are more curved and the anterior surface is advanced. The iris is broader, and at its pupillary border is displaced forward, at its ciliary border, backward.

being increased at the expense of the lateral diameter. Coincidently with the change in the convexity of the lens there is contraction of the pupil, the anterior chamber becomes shallow, and in binocular vision there is convergence of the visual lines.

The *far point*, or punctum remotum, is the point at which distant objects can be distinctly seen by an eye in a state of complete rest. Infinity is the far point of an emmetropic eye.

The *near point*, or punctum proximum, is the nearest point at which objects can be seen by an eye during full accommodation. It may easily be ascertained by determining the shortest distance at which the smallest Snellen type on a reading card can be seen.

The *range of accommodation* is the distance between the far point and the near point.

The *amplitude of accommodation* is the difference in the refraction of the eye when in a state of complete rest and when in a condition of maximum refraction. The strength of the lens necessary to take the place of accommodation when placed before the eye represents the amplitude or power of accommodation. The amplitude of accommodation may be easily determined by dividing the distance of the near point, taken in centimeters, by 100. This rule is applicable in emmetropia.

The amplitude of accommodation decreases and the near point recedes as age increases, owing to diminution of the elasticity of the lens. After the age of forty-five years this condition is very frequent, and is known as presbyopia. The following table illustrates the influences of age upon accommodation :

YEAR.	Near point.	Amplitude in diopters.	YEAR.	Near point.	Amplitude in diopters.
10	7.0 cm.	14.0	45	28.0 cm.	3.5
15	8.5 "	12.0	50	40.0 "	2.5
20	10.0 "	10.0	55	55.0 "	1.75
25	12.0 "	8.5	60	100.0 "	1.0
30	14.0 "	7.0	65	133.0 "	0.75
35	18.0 "	5.5	70	400.0 "	0.25
40	22.0 "	4.5			

The full power of accommodation is seldom utilized, as about one third is held in reserve to permit the continuous performance of near work without distress.

In hyperopia a certain amount of accommodation is used to correct distant vision, so that the near point with the same amplitude of accommodation is farther away than in emmetropia. This constant strain upon the ciliary muscle tends to hasten presbyopia.

In myopia the near point is closer than in emmetropia for the same age. This allows the power of the ciliary muscle to be held in reserve, so that presbyopia is somewhat retarded.

Convergence.—In monocular vision the phenomena of accommodation occur without any change in the direction of the visual lines, but in binocular vision it is necessary for the visual axes to be directed toward each other or converged for the perfect perception of near objects. At a distance of 6 meters the visual lines may be considered as parallel, but as the object approaches the eye the convergence increases. It usually bears a harmonious re-

lation to accommodation, but may occur independently, as when mydriasis is present.

The *angle of convergence* is the angle which the visual line makes in turning from distant to near objects. The unit is the meter angle, which is the angle formed by the visual line with the median line when the eyes are directed toward an object at 1 meter distance. The degree of convergence may be easily ascertained by placing prisms of varying strengths before the eyes.

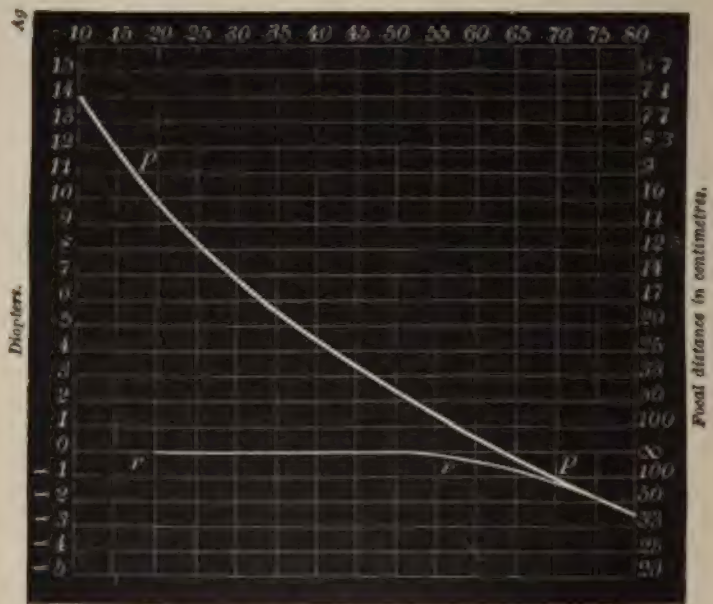


FIG. 210.—RANGE OF ACCOMMODATION AT DIFFERENT AGES. (After Donders.)

The relation between accommodation and convergence is such that 1 degree or meter angle of convergence is necessary for every diopter of accommodation in the emmetropic eye.

Negative convergence is present when the visual lines are parallel; *positive convergence* exists when there is any inward deviation of the visual lines.

Relative accommodation is the power of altering the accommodation without changing the convergence.

Visual Acuity.—In all diseased conditions of the eye it is important to determine the acuteness of vision, as in this man-

ner the degree of functional impairment is ascertained. The essentials for distinct vision are clear media, regularity of the refracting curvatures, and the perfect collection or focusing of the rays of light upon the maculæ of both eyes.

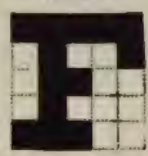


FIG. 211.—A LETTER FROM SNELLEN'S TEST CARD.

The systematic examination of the eyes of school children represents a great advance in many of our cities, and both the profession and the public itself owe much to the labors of Dr. Frank Allport, of Chicago, and Dr. S. D. Risley, of Philadelphia. Some of the tests are now compulsory in several States.

The macular region is the most sensitive portion of the retina to light. The cones which are the essential elements to visual perception are about 60 in number at this point, each being 3 micromillimeters in size and having an interval of but 0.002 mm. between them. In order that an object may be distinctly seen, it has been ascertained that it must subtend an angle of at least one minute or be 4 micromillimeters in size.

FIG. 212.—TEST CARD.

The methods employed for the determination of the acuity of vision make use of this fact in the construction of test letters, each limb of which subtends an angle of one minute, and the whole letter subtends to an angle of five minutes (Fig. 212). Snellen's types are so constructed and are most commonly employed for ascertaining the acuteness of vision. The letters may be white upon a black background or black upon a white background. For use among illiterate people a card upon which a number of E-shaped figures are printed is used. These figures are of various sizes in accordance with the Snellen principle and point in different directions; the patient is requested to show the direction in which the limbs of the figures point. Cards with letters reversed are also constructed for use in small rooms, where

parture from this condition that results in imperfect or blurred images constitutes *ametropia.* In addition to blurring of vision, ametropia is accompanied by various symptoms referable to eye-strain. *Asthenopia* is the term applied to this group of symptoms. Ametropia is of three varieties: *hyperopia, myopia, and astigmatism.*

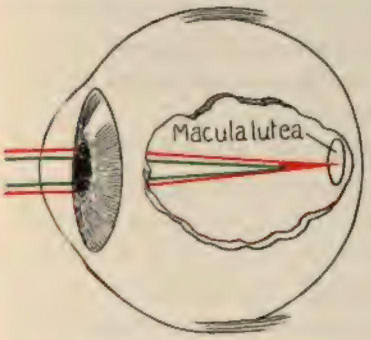


FIG. 214.—EMMETROPIA.
Principal focus on macula.

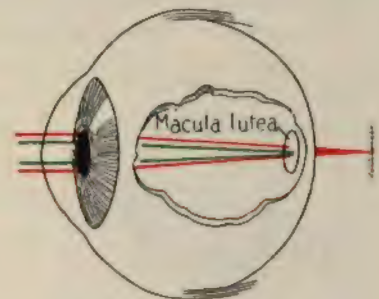


FIG. 215.—HYPEROPIA.
Macula in front of principal focus.

Hyperopia is a form of ametropia in which the length of the eyeball does not correspond to the focal length of the dioptric system of the eye, and in which the principal focus, therefore, lies behind the retina. It may be due to the eyeball being shorter than normal, unusual curvature of the cornea or lens, or an increase in the density of the refracting media.

Hyperopia is nearly always a congenital defect, most children being born far-sighted. As the child grows, the eyeball elongates proportionately and emmetropia soon follows. Sometimes by reason of excessive near work myopia supervenes. As age advances—that is to say, after forty-five years—hyperopia again asserts itself. It is also present to a marked degree in eyes from which the lens has been extracted, as in cataract.

In a state of rest the hyperopic eye is able to focus rays from a distance that are already convergent. With the aid of an ordinary degree of accommodative power the near point will be found to have receded and close vision will be blurred. By an excessive amount of accommodation the distance vision may be brought to normal, together with improvement of close vision at the proper near point. The increase of work placed upon the ciliary muscle causes hypertrophy of its circular fibers, and consequently the

ciliary muscle forms an obtuse angle with the iris. By reason of the abnormal functional activity of the ciliary muscle, failure of accommodation is often hastened, resulting in presbyopia at an earlier age than in emmetropia.

In uncorrected hyperopia, convergence increases with the increase of accommodation by reason of the relation existing between them, so that internal strabismus or squint is often seen as a consequence. This is at first well marked only for near points, but later becomes manifest for distance as well.

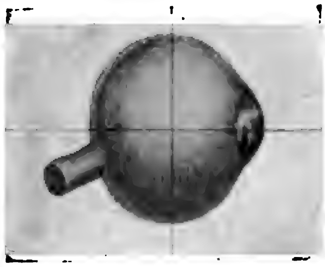


FIG. 216.—HYPEROPIC EYE.

The hyperopic eye (Fig. 216), as ordinarily seen, presents certain characteristics which serve to distinguish it. The orbit in which it it contained is always more shallow than normal, and the length of the eyeball is less than in emmetropia. There is always a sharp curvature at the equator of the globe and the sclera is unusually thick. The anterior chamber is shallow and the pupils are small. The overgrowth of the circular fibers of the ciliary muscle is a constant accompaniment in uncorrected hyperopia of long duration.

Hyperopia may be of two varieties: *latent*, in which the error of refraction is overcome and disguised by the action of the ciliary muscle, and *manifest*, in which the refraction defect is uncorrected by accommodation. These varieties usually exist more or less combined.

In manifest hyperopia the vision for distance and near is indistinct, and more or less pain in the eyes and head may be present. Three forms of manifest hyperopia have been described, *facultative, relative*, and *absolute*. Facultative hyperopia is that form in which an extra effect of accommodation may conceal the error without causing squint. Relative hyperopia requires undue convergence with the extra accommodative effect to overcome it, and internal strabismus or squint follows. Absolute hyperopia is that variety in which the accommodation has no effect.

Symptoms.—The manifestations of hyperopia are great in number, and are mostly referred to the excessive strain upon the ciliary muscle. The vision for objects at close range is nearly

always blurred, or becomes so in a very short time. Reading of small print quickly tires the eyes and gives rise to drowsiness. The lids become heavy, and the eyes ache and burn if the near work is continued. In order to see more distinctly, affected persons hold their reading material very close to the eyes in a strong light. This causes the pupils to become contracted and the fissure between the lids (*palpebral fissure*) becomes narrow. Headache is frequent, and is usually frontal, but may be situated elsewhere. Neuralgia of the face or head may also occur as the result of eye-strain.

The continuous contraction of the ciliary muscle invites an increased amount of blood to the eye, causing congestion of the various portions of the eye. The optic disk becomes hyperemic, the retina is hazy, and the choroid is congested and granular in aggravated cases. The eyelids are red and feel heavy, and congestion of the conjunctiva is present. The vascular spaces of the iris are overfilled by the almost constant contraction of

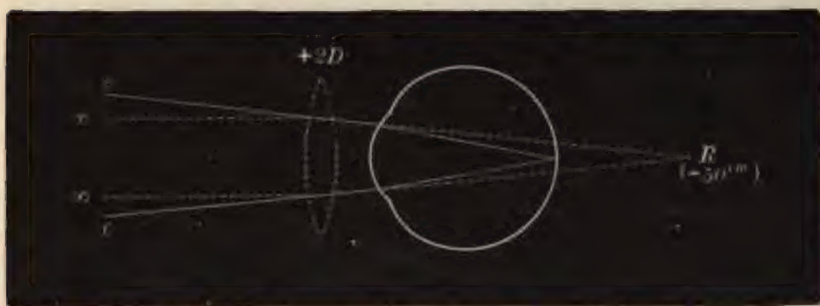


FIG. 217.—CORRECTION OF HYPEROPIA BY A CONVEX LENS.

the pupil, as is shown by the slight ciliary injection. This general congestion of the eyeball tends to prolong and exaggerate any existing inflammation of any portion of the eye, or may act as a causal factor in its production.

In instances where the hyperopia is overcome without much congestive or visual disturbance it frequently happens that the excessive work of the ciliary muscle is manifested through the nervous system by various neurotic symptoms. Among these may be mentioned photophobia, headache, twitching of the lids, nausea, vertigo, vomiting, etc.

of light which pass out of the eye from the fovea become convergent and meet at some point inside of infinity.

The range of distinct vision is always less than normal, the near and far points of the eye being closer to the eye than in emmetropia. Near work can be performed without the aid of accommodation, and results in insufficiency of convergence, which may be followed by external squint. In low degrees of myopia the accommodation is often quite active and may exaggerate the near-sightedness. Usually, however, the accommodation is small, the circular fibers of the ciliary muscle are not prominent, while the longitudinal fibers are somewhat hypertrophied. This disuse of the ciliary muscle has one advantage: it retards presbyopia.

FIG. 219.—MYOPIC EYE.

The placing of a concave lens before a myopic eye causes the rays of light to diverge, and a clear image is formed by their focus on the retina.

The similar use of a convex lens causes increased convergence of the rays with a corresponding increase of the myopia.

Etiology.—Myopia may be due to increased refraction of the dioptric system or increased length of the optical axis. The increased refraction may be caused by changes in the corneal curvature, as seen in conical cornea and staphyloma, by swelling of the lens, as in incipient cataract, giving rise to the so-called "second sight," and by increased curvature of the lens following spasm of the ciliary muscle, and diseases, such as cyclitis and iridocyclitis, which cause relaxation of the suspensory ligament of the lens. The ordinary myopia is usually due to an abnormal length of the eyeball.

The cause of the elongation of the eyeball in myopia has been the subject of considerable discussion, resulting in the acceptance of three theories:

1. *The anatomical theory*, which holds that the eyeballs elongate by reason of the large size and peculiar shape of the orbits. No resistance is afforded the growth of the eyes.

2. *The mechanical theory*, which ascribes the length of the

eye to compression between the external recti muscles and the orbit by the excessive convergence necessary to perform work at close distance. The lateral pressure causes the coats of the eyeball to be distended backward because the resistance is least at the posterior pole.

3. *The inflammatory theory*, in which the cause is believed to reside in a low grade of inflammation of the ocular tunics, most marked at the posterior pole of the eye. Macular choroiditis is a form of this inflammation. The inflammation is usually preceded by congestion of the retina and choroid as the result of excessive and improper use of the eyes. The inflammation slowly supervenes, but never becomes active. Myopia in growing children is undoubtedly due to this cause. At birth, hyperopia is the rule and emmetropia follows with the subsequent growth. If the child is made to perform excessive near work under bad conditions, such as poor light, improper ventilation, imperfect posture, etc., congestion of the eyeball occurs posteriorly and becomes constant, soon passing into inflammation. The hygiene of the child, if improper, is a factor of great importance in the production of myopia. The infectious fevers often cause a change in the refraction of children's eyes, but this is probably due to the too early resumption of close work during convalescence. During this period the tunics are weak and easily distended by moderate strain.

The **clinical forms of myopia** are static, functional, progressive, and malignant myopia. *Static* or *true myopia* is the term applied to the ordinary variety due to enlongation of the axis of the eye. *Functional myopia* is due to spasm of the ciliary muscle, conical cornea, swelling of lens as in incipient cataract, etc. *Progressive myopia* is that form in which the error increases progressively from year to year accompanied by destructive changes in the choroid and other parts of the eye and by marked impairment of vision. *Malignant myopia* is progressive myopia when it runs a rapid course ending in blindness.

Symptoms.—One of the most marked symptoms of myopia is the blurring of distant vision, which gives rise to a false estimation of the magnitude and distance of objects. The interpretation of perceptions is always delayed. On account of the near point being closer than normal the patient is compelled to hold

reading materials or other close work very near to the face, the head moving from side to side in following each line. Pain over the eyes, photophobia, photopsia, metamorphopsia, etc., may be present as structural changes in the coats of the eye advance.

Headache and reflex phenomena are uncommon in myopia uncomplicated by astigmatism on account of the very small amount of work placed upon the ciliary muscle.

The expression of a myopic individual is peculiar and characteristic. The face is broad and gives the patient the appearance of being stupid. The eyeballs protrude and the interpupillary space is wider than normal. The pupils are dilated, the anterior chamber is deep, and the lids are squeezed together over the eye to cut out the excess of light, and to increase the visual acuity.

Myopia is a disadvantage at all times because the patient is unable to engage in outdoor games or pursuits without wearing glasses. This is followed by a tendency to perform an undue amount of close work, which has a bad effect upon the existing myopia. Persons who perform intellectual work are the most common subjects of myopia, but it is also frequent among the tailors, particularly of the lower class of Jews, who are compelled to perform considerable work in constrained positions under poor light. Violent exercise or work in myopes may be followed by choroiditis, detachment of the retina, or rupture of the choroid. There are but two advantages of myopia: presbyopia is retarded and glaucoma is infrequent.

Ophthalmoscopic Appearance.—Examination of the myopic eye by means of the ophthalmoscope nearly always shows thinning of the choroid and sclera. The choroid seems to be drawn to the temporal side of the disk, producing a crescentic space of whitish or grayish color at the outer side of the nerve head. This crescentic patch is known as the conus or myopic crescent, and is due to the sclera showing through the atrophied choroid. The head of the optic nerve is not infrequently distorted to correspond to this apparent distortion of the choroid. Sometimes true myopia is accompanied by a curvilinear reflex at the nasal side of the disk (Weiss reflex), and when seen may aid in the early recognition of the condition. It is considered by some as a symptom of progressive myopia.

In high-grade myopia the tunics are so diseased that the lat-

eral pressure of the muscles causes the atrophied choroid an thinned sclera to bulge posteriorly in the region of the op nerve, giving rise to posterior staphyloma. Patches of atrophied

Fig. [illegible].—Posterior Staphyloma. Myopic Eye. ([illegible].)

choroid, with sclera showing through, and pigmentary changes may be scattered throughout the whole eye-ground. The vitre-

ous soon becomes semifluid and floating opacities are found in it (cholesterin crystals, etc.; see Diseases of the Vitreous). The retina will become detached if the myopia progresses, and opacities of the lens will often follow. The vision fails according to the degree of structural change in the macular region.

Diagnosis.—The diagnosis of myopia is made by the acceptation of a concave lens by the patient with or without a mydriatic, with improvement of distance vision. The retinoscope and ophthalmoscope may be employed as confirmatory tests.

Prognosis.—The prognosis in low forms of the condition is very favorable, provided the treatment is prompt and carefully conducted. Progressive myopia is always a serious condition, and often advances in spite of the best treatment. Malignant myopia is a hopeless affection. Myopia in children and young adults is more serious than in persons past thirty years of age, as the condition usually becomes stationary at this time.

Treatment.—The treatment consists in wearing the weakest concave lens which gives best distance vision and which corresponds to the far point, together with reducing the amount of near work, and employing appropriate measures for preventing the disease's progress.

To obtain the strength of the correcting lens, the eyes should be examined while under the influence of a mydriatic, otherwise

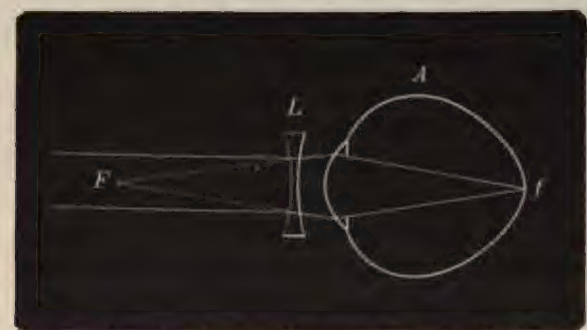


FIG. 221.—CORRECTION OF MYOPIA BY A CONCAVE LENS.

too strong a glass will be accepted. In low degrees the full correction should be worn constantly. If over 4 diopters of myopia are present, full correction is necessary for distance only, while for near a reduction is made, so that reading material can be

held at a distance of about 13 inches from the eye. In presbyopia it is necessary to add convex lenses to the myopic correction to afford comfortable reading. If there is much divergence, prisms should be ordered or the lenses should be decentered. In divergence of more than 10 degrees some muscle operation should be performed.

The preventive measures in the treatment of myopia consist largely in rendering the near work less injurious. When symptoms are pronounced, it should be temporarily suspended. It is necessary at all times to keep growing children in the best of health, so that their eyes will be in condition to resist the ordinary strain placed upon them. During convalescence of the infectious fevers or other illness the child should not be allowed to read, write, or study, except very moderately. Fresh air, tonics, good food, outdoor exercise, etc., are necessary at this period to restore tone to the weakened physical condition.

School children should be carefully watched; the first signs of failing vision necessitate the consulting of an oculist. The light of the school room should enter from two sides, preferably the north and the east. The pupil sits facing the east while the light falls on the left side of the book or slate. Not less than 1 square foot of window glass should be allowed for 5 square feet of floor space. The ceilings and walls should be dull white in color, and adjoining buildings which encroach on the light space should also be painted white.

The desks should be sloping and of sufficient height to prevent undue stooping over. A highly polished desk surface is harmful in that it causes considerable reflection. The chairs should allow the feet to touch the floor.

The books used by the scholars should be printed upon unglazed paper; the type should be broad faced and the ink black.

Astigmatism is a form of ametropia in which rays of light entering the eye are refracted differently in the various meridians. It bears no relation to the length of the eye. The meridians of greatest refraction and that of least refraction are known as the two principal meridians and are at right angles to each other.

A small degree of astigmatism exists in every eye due to irregularities in the curvature of the lens, or cornea, or both.

Frequently the lenticular astigmatism neutralizes that of the cornea and thus evades detection. The extra-ocular muscles in exercising their function also produce a physiological form of astigmatism.

The condition seldom exists alone, but is usually combined with myopia or hyperopia. It is most frequently a congenital defect, but may be acquired by injury or disease of the eyeball. An excess or diminution of orbital fat aids in changing the curvature of the eyeball, but more commonly it is due to ulcers

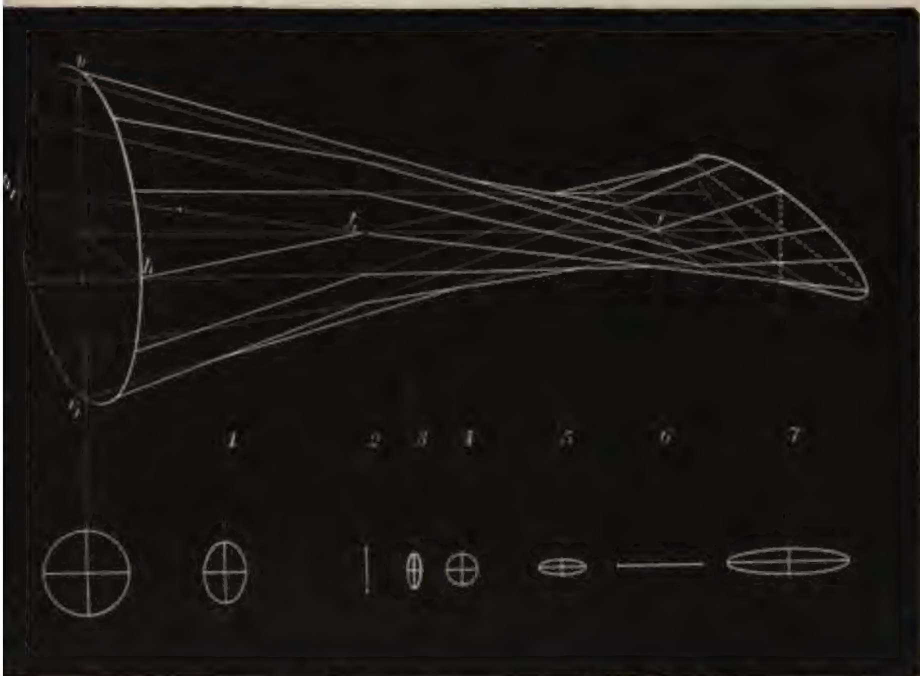


FIG. 222a.—REFRACTION OF THE RAYS IN REGULAR ASTIGMATISM.

or wounds of the cornea. The scars following ulcers or wounds while undergoing absorption produce astigmatism, which varies in degree as absorption progresses. This is best seen after the removal of a pterygium encroaching on the cornea and after cataract operations. The pressure of swollen eyelids or a chalazion gives rise to a temporary astigmatism which disappears as the cause is removed. Swelling of the lens is also a factor in its production. Operations upon the extra-ocular mus-

cles are followed by astigmatism on account of the disturbance of pressure thus produced. Astigmatism may also be produced voluntarily by pressure upon the eyeball with the finger.

There are two principal varieties of astigmatism, regular and irregular.

Irregular astigmatism consists in variations in refraction along the course of one or more meridians. Different parts of the same meridian have different refractive powers, and blurred images are formed that cannot be improved by glasses. It is usually due to some pathological change in the cornea or lens.

Regular astigmatism is that form in which there is a difference in the refraction of the principal meridians. It is the most common variety.

Parallel rays passing through a spherical surface form a circular cone and are brought to a focus at a point, but in astigmatism, owing to the principal meridians having their principal foci at different points, the resulting cone will be oval and the images will be more or less elongated. This is best shown by having an astigmatic individual look at two lines crossed at right angles. The vertical line is refracted through the horizontal meridian and the horizontal line through the vertical meridian. If one meridian is curved more than the other, the line seen through this meridian will be blurred and indistinct, and the lines parallel to the ametropic meridian will be seen most clearly.

FIG. 222b.—RETINAL IMAGES IN REGULAR ASTIGMATISM.

A, two lines placed perpendicular to each other; *B*, their image upon the retina of an astigmatic person.

Regular astigmatism may be subdivided into simple, compound, and mixed. *Simple astigmatism* is present when one principal meridian is emmetropic and the other is hyperopic or

myopic. *Compound astigmatism* is the form in which both principal meridians are myopic or hyperopic, but of different degrees. *Mixed astigmatism* consists of hyperopia in one meridian with myopia in the meridian at right angles to the first.

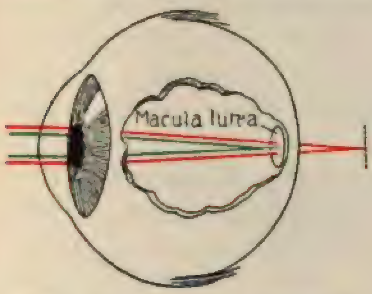


FIG. 223.—SIMPLE HYPEROPIC ASTIGMATISM.

Red line is hyperopic meridian; green line is emmetropic meridian.

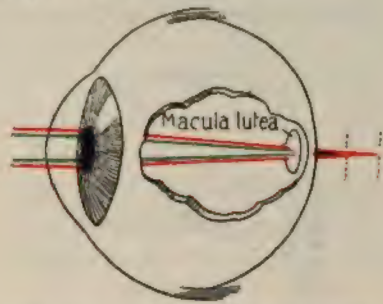


FIG. 224.—COMPOUND HYPEROPIC ASTIGMATISM.

All meridians are hyperopic, as indicated by both red and green lines projecting beyond macula.

Simple Hyperopic Astigmatism.—In this condition one meridian is emmetropic (usually the vertical), the other being hyperopic. The focus of the emmetropic meridian is on the retina, while the focus of the horizontal meridian is posterior to the retina.

Compound Hyperopic Astigmatism.—This is the most common of all refractive errors in the United States. In this form all meridians are hyperopic, the horizontal usually more than the vertical (Fig. 224). Parallel rays of light passing through each principal meridian focus behind the retina, the horizontal one being usually behind the vertical.

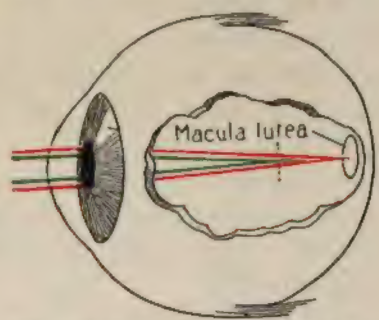


FIG. 225.—SIMPLE MYOPIC ASTIGMATISM.

One meridian in front of macula, coming to focus at dotted line; the other emmetropic, on macula.

Simple Myopic Astigmatism.—The focus of parallel raysof light passing through the vertical meridian lies in front of the retina, while the focus of the horizontal meridian is on the retina (Fig. 225).

of the margins of the lids, are also manifestations of astigmatism. In delicate persons of neurotic temperaments various reflex disorders may occur, which are relieved only by the wearing of cylindrical lenses. Nausea, indigestion, anorexia, etc., are frequent, and the patient often inclines the head toward one side in reading. The examination of the fundus always shows more or less distortion of the head of the optic nerve and blurring of the vessels in a direction corresponding to the meridian of least refraction.

Astigmatism should always be considered when the application of spherical lenses fails to increase the vision, but no tests are entirely satisfactory unless the eye is placed at rest under the influence of a cycloplegic.

The *astigmatic dial* in which straight lines radiate from a center and are numbered at the periphery, similar to a clock

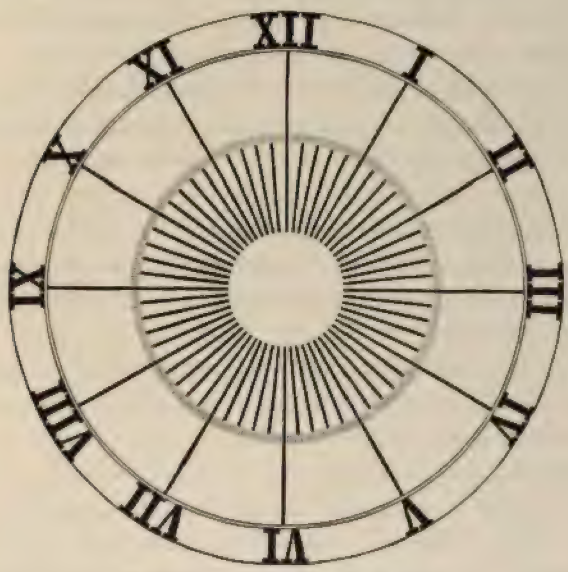


FIG. 228.—ASTIGMATIC DIAL.

dial, is of great value in determining astigmatism. The lines most clearly seen correspond to the meridian of greatest refraction. The amount of astigmatism is indicated by the cylindrical lens placed before the eye with its axis at right angles to the lines most distinctly seen, which causes all the lines to be seen

with equal clearness. The test letters of Dr. Pray are made up of lines inclined at various angles and are used in a similar manner.

The *stenopæic slit* consists of a metal disk with a slit in one of its diameters. As in all examinations for ametropia, the patient is seated at a distance of 6 meters from the test-card and the slit, $1\frac{1}{2}$ mm. in width, is inserted in the trial frame, each eye being tested separately. The slit is then rotated until the letters are most distinctly seen. This position of the slit indicates the meridian of least refraction. The vision should then be improved by lenses until normal. The slit is again rotated until at right angles to the first position. This is the meridian of greatest refraction, and should also be corrected until the vision is normal. The refraction of the first meridian indicates the strength of the spherical lens, if any is required, while the difference between the refraction of the first and second meridian equals the strength of the cylinder. The axis of the cylinder always corresponds to the meridian of least refraction.

Test-cards with *confusion letters* printed upon them are also frequently employed. The letters used are those that resemble each other closely, and the patient is asked to select a cylinder that removes the confusion.

Other tests, such as the corneal reflex, Placido's disk, chromo-aberration test, and Thomson's ametrometer, are sometimes used, but possess no advantage over some form of the astigmatic dial and are less accurate.

The use of the ophthalmoscope, retinoscope, and ophthalmometer in connection with astigmatism will be discussed under separate headings.

The treatment of astigmatism is always satisfactory, and consists in wearing a cylindrical lens which prevents confusion of letters or lines. The axis should be determined with certainty by repeated examinations, and any change in the general health indicates further examination to determine whether the axis has remained stationary. The glasses should be worn constantly.

Anisometropia is the term generally applied to marked inequality in the refraction of the two eyes. Accurately speaking, the term anisometropia should be applied where the two

eyes differ in the same variety of ametropia, while the terms *heterometropia* (Parker) or *antimetropia* (Suker) are to be employed where the error of refraction is of a different kind in each eye; as, for instance, myopia in one eye and hyperopia in the other. Both may be met with under three conditions: (1) Binocular vision is present; (2) the eyes are used alternately; (3) one eye is permanently excluded from vision. Slight differences exist in most eyes and may be disregarded. Various combinations of myopia, hyperopia, and astigmatism may be present and binocular vision may be good. Usually the vision of the worst eye is suppressed or the eyes are used alternately. This is the condition which exists in most cases of internal squint in growing children. When binocular vision is present in differences of low degree full correction of the refraction error should be prescribed. In higher grades partial correction is sufficient. If binocular vision is absent, the correcting glass should be applied to the best eye, but if vision is present in the other eye it may be increased by the wearing of a correcting lens, and by exercising it while the better eye is closed by a blinder. Careful examination into the refraction in all cases of squint will show more or less anisometropia, but the rules just given are subject to considerable variation in its correction.

Asthenopia is the technical name for the group of symptoms resulting from eye-strain due to errors of refraction or fatigue of the ocular muscles. It usually arises from excessive use of the eyes in individuals, the subject of errors of refraction or some disturbance of the extra-ocular muscle-balance. For convenience of description it may be divided into accommodative, muscular, and retinal asthenopia. *Accommodative asthenopia* is due to excessive functional activity of the ciliary muscle in attempts to correct hyperopic defects of the dioptric system. *Muscular asthenopia* results from insufficiency, incoördination, weakness, and strain of the external muscles of the eye. It is a common symptom of myopia. *Retinal asthenopia* is manifested by haziness and dimness of vision, photophobia, and pain, and is caused by fatigue and exhaustion of the nerve elements concerned in vision. As in other nerve structures, it may manifest itself as hyperesthesia, anesthesia, or paresthesia of the retina. The "gold blindness" which occurs in dentists may be mentioned as an

example. Overworked school children and clerks may also be affected, and an exaggerated form is sometimes present in hysterical individuals.

The symptoms may be visual, congestive, or reflex. The *visual symptoms* consist largely in an inability to read for any length of time, particularly at night, without blurring of letters and drowsiness. Photophobia, flashes of light, and floating specks before the sight, double vision, etc., also belong to this class. The *congestive manifestations* include congestion of the lids, conjunctiva, iris, and other parts of the eye predisposing to inflammation, and aggravating any such condition present. The formation of styes, chalazia, and crusts upon the lids is usually due to ametropia. The *reflex symptoms* include headache, neuralgia, anorexia, dyspepsia, nausea, vomiting, choreiform attacks, insomnia, nightmare, etc. The severity of the symptoms bears a direct relation to the general and neurotic temperament of the patient. Small errors of refraction in nervous women frequently produce very alarming symptoms.

The treatment consists in rest with the proper correction of the ametropia supplemented by measures which will tend to improve the general health.

ANOMALIES OF ACCOMMODATION

The function of accommodation is subject to two variations: it may be diminished or increased. Diminution of accommodation may be brought about by advancing age, drugs, infectious fevers, injuries, and constitutional disorders. An increase is caused by uncorrected errors of refraction and drugs.

Presbyopia.—The lessening of the power of accommodation that occurs as age advances is physiological and is known as *presbyopia*. It begins after forty years of age and steadily progresses, being most marked in hyperopic persons. The most prominent symptom is the recession of the near point beyond the customary reading distance.

The cause of presbyopia lies in the progressive loss in the elasticity of the crystalline lens which begins at this time of life. This loss may be hastened by the excessive functional activity of

the ciliary muscle, as in hyperopia. Myopia tends to retard failure of accommodation.

The condition usually takes place to the same degree in both eyes except in high grades of anisometropia. Under ordinary circumstances both eyes may be tested at the same time, but if one eye is myopic and the other hyperopic each eye should be tested separately. In addition to recession of the near point there is always blurring of print, and considerable fatigue follows the use of the eyes even if moderate. Asthenopic symptoms are present in all degrees of uncorrected presbyopia.

The correction of presbyopia consists in wearing convex glasses that give good vision for ordinary working distance. To determine the strength of such correcting lenses the eyes are examined without the aid of a mydriatic. The distance vision is taken, and any hyperopia or other refractive error is ascertained and corrected. It is important to do this at all times, as certain forms of ametropia become manifest as accommodation fails which were previously disguised. Convex glasses are then added that bring the near point to about 13 inches for ordinary reading. The exact location of the near point depends upon the patient's occupation; the variation is obvious in musicians, machinists, typewriters, engravers, etc.

The exact strength of the lens necessary to correct presbyopia may be ascertained by subtracting the strength in diopters of the lens, the focal distance of which is equal to the patient's near point, from the strength of the lens whose focal distance corresponds to the distance at which the patient may perform near work with comfort. The remainder equals the strength of the lens to be added to the distance correction. For example, if the near point is at 50 cm. the corresponding lens is 2 diopters; the point at which the patient wishes to perform close work is 33 cm., which is the focal distance of a lens 3 diopters. Subtracting 2 diopters from 3 diopters equals 1 diopter, the strength of the lens necessary.

The progression of presbyopia requires repeated examinations of the eyes about once every two years, as the rate of the failure of accommodation is about 1 diopter for every five years after forty years of age.

Age.	Failure of Accommodation.
45	1 D.
50	1.75 to 2.00 D.
55	2.50 to 3.00 D.
60	3.00 to 4.00 D.
65	3.50 to 4.50 D.

The diminution of accommodation induced by the action of drugs is nearly always complete, and is spoken of as *paralysis of accommodation*, being due to palsy of the ciliary muscle. Drugs having such action are called *cycloplegics*. They also cause dilatation of the pupil or *mydriasis*. The principal drugs of this class are atropin, bromid of methyl atropin, euphthalmin, homatropin, scopolamin, hyoscyamin, and daturin. They are employed in solution. Their effect is produced usually by instillation into the conjunctival *cul-de-sac*, but may be caused by the administration of toxic doses internally.

Paralysis of accommodation by drugs is indicated for the determination of ametropia, in persons under forty years of age, that may be masked by the action of the ciliary muscle, and also in inflammatory diseases of the eye where absolute rest is required. The use of a cycloplegic is dangerous after the age of forty years on account of the tendency toward glaucoma at this period.

For practical purposes the most important cycloplegics are atropin, homatropin, and scopolamin, on account of the certainty of their action.

Atropin sulphate is usually employed in the strength of 4 gr. (0.24) to the ounce (30.0), and should be instilled by means of a medicine dropper. The upper eyelid should be held up while the patient looks down, the drop being placed on the sclera at the corneal margin. Absorption takes place through the cornea and blood-vessels at the sclerocorneal junction. One drop of the atropin solution should be instilled 3 times daily for at least twenty-four hours before the examination. The pupil is dilated at the end of twenty-two minutes after the first drop, and the drug induces paralysis of accommodation in about forty-six minutes. The maximum effect lasts about four days, after which it gradually diminishes and is absent in about ten days after the last instillation. In susceptible individuals the paralysis lasts a longer

period, and sometimes flushing, rapid pulse, dizziness, dryness of throat, and slight delirium are present. The administration of some preparation of opium has an antidotal effect, but is seldom necessary, as the symptoms soon subside with the withdrawal of the drug.

Homatropin is more rapid in its action and less lasting in its effect, and on this account is preferred for ordinary examination. It is used in the strength of 10 (0.6) to 15 grains (1.0) to the ounce, alone or combined with cocain. Dilatation of the pupil occurs in thirty minutes and cycloplegia is complete in one hour. The effect of the drug lasts but a few hours, and is entirely absent at the end of twenty-four hours. It may be instilled every fifteen minutes for two hours, or at longer intervals covering twenty-four hours. Dryness of the throat and flushing of the face occasionally occur, but a more frequent symptom is intense congestion of the conjunctiva. This congestion is relieved by the instillation of a drop of a 4-per-cent cocain solution. Adrenalin is also employed for the purpose.

Scopolamin is usually employed in the strength of one half grain (0.03) to the ounce (30.0). Its action begins in from seven to ten minutes, and is complete in about half an hour. The effect lasts about twelve hours and gradually diminishes, being lost at the end of five days. It has the great disadvantage of producing alarming symptoms in susceptible individuals.

Euphthalmin is generally used in the form of a hydrochlorid. A 5-per-cent solution will produce dilatation of the pupil *ad maximum* within a half hour, disappearing again in from six to seven hours. The addition of cocain increases its mydriatic effect. Its cycloplegic action is so slight that it is practically of value only as a means for facilitating the examination of the eye.

All persons under the influence of a mydriatic should wear *plane dark glasses* and abstain from attempting any close work until the accommodation is restored. As all cycloplegics are powerful poisons great care should be exercised in using them to prevent accidents. Their internal administration in toxic doses also induces cycloplegia.

Drugs such as gelsemium and conium, when administered internally in toxic doses also have the power of arresting accommodation by their action on the oculomotor nerve.

Pathological cycloplegia may be applied to the paralysis of accommodation which follows local or general diseases. The third nerve is usually involved in its distribution to the ciliary muscle, and the paralysis may follow diphtheria, influenza, injuries to the head or eyeball, diabetes, syphilis, tumor of the central nervous system, or extreme general debility. The symptoms are the same as in other forms of paralysis of accommodation, and the treatment should always be directed toward the original cause, tonics and stimulants being necessary in all cases. The outlook is favorable in most cases, but in those due to traumatism the prognosis should always be guarded. Myotics may be employed, but are seldom necessary.

Increase in the function of accommodation is due to spasm of the ciliary muscle, and may be brought about by excessive eye-strain and certain drugs. Children and young adults often overcome slight degrees of ametropia in this manner. Constant application to close work and poor light are also factors of importance in its production. Both eyes are affected and convergence is intensified, often causing diplopia. Asthenopia and blurring of vision promptly follow. Atropin should be instilled in all cases, and the proper correction should be prescribed.

[illegible]

[illegible]

METHODS FOR THE DETERMINATION OF THE REFRACTION OF THE EYE

[illegible]

any other data that may possibly influence the ocular condition. As the ultimate aim of ophthalmology is to increase and maintain vision, the visual acuity for distance and near should be taken at all times and recorded on the history chart. A mydriatic should then be prescribed, if the patient is not over forty-five years of age, to place the eye at rest in order that latent errors may be more easily detected. This procedure necessitates a total suspension of near work for a period varying from twenty-four hours to two weeks, depending upon the drug employed. The patient should be instructed concerning this effect of the drug in order to avoid undue anxiety and alarm.

After mydriasis is complete the vision should be taken again; usually it will decrease for distance in hyperopia and increase in myopia, while in simple astigmatism and emmetropia it remains unchanged. The placing of a pinhole disk before the eye will increase the visual acuity if the eye-ground is normal.

FIG. 229.—TRIAL LENSES.

The examination of the refraction may be subjective or objective. The subjective examination includes the use of the test letters and trial lenses, while the objective examination is made by the aid of the ophthalmoscope, retinoscope, and the ophthalmometer.

Trial Lenses.—A case of trial lenses should consist of a number of pairs of plus and minus spherical lenses ranging from 0.12 D. to 20.0 D., a smaller number of plus and minus cylindrical lenses, also in pairs, ranging from 0.12 D. to 6.0 D., a row of prisms varying from 0.5 to 20.0 degrees, various opaque and colored glasses, perforated disk, stenopeic slit, blinders, and a trial frame.

The mechanism of the trial frame should be as simple as is compatible with accurate work, as the presence of a number of screws, etc., hamper the examination by their continually getting out of order. The frame should be so arranged that the cells holding the lenses may be raised or lowered or may be brought together or separated when centering the lenses before the eyes. Two cells should be provided in the frame for holding the lenses, and hooks should be placed on the front of the frame to receive any additional lens necessary. The scale markings on the front are used to denote the axis of astigmatism, and those before the left eye should begin at zero on the nasal side and run to 180 on the temporal side, while those before the right eye begin at zero on the temporal side. A failure to remember this will cause confusion in ordering cylindrical lenses, particularly in the United States, where this system of marking is employed almost exclusively.

The trial frame should be adjusted accurately when placed before the eyes, so that the pupillary centers will correspond to the centers of the lenses employed in testing, and the distance from the anterior surface of the cornea to the cells of the trial frame should approach as near as possible to the distance between the cornea and the glasses which will afterwards be worn. The importance of this is shown by the fact that the effect of a convex glass is increased if carried away from the eye, and that of a concave lens is lessened by moving it away from the eye.

In proceeding with the examination of the refraction each eye should be tested separately, and after the vision has been taken efforts should be made to improve it by alternately placing before the eye plus and minus spherical and cylindrical lenses. For this purpose lenses of the strength of 0.25 D. should be employed, and whichever is selected by the patient should be further increased until the vision is no longer improved. Occasion-

ally lenses of 0.12 D. strength are used, but the differences caused by them is often imperceptible, and the constant changing of the lenses serves to worry the patient.

If spherical lenses are selected and increased until there is no further improvement, and the vision is not yet normal, compound astigmatism should be suspected. Cylinders beginning with + 0.25 D. and — 0.25 D. should be placed alternately before the eyes at the normal axes—that is, 90 for the plus cylinder and 180 for the minus, and increased in the same manner as spherical lenses. If no improvement follows, the cylinders should be rotated until a point is reached at which it is produced. This axis will be indicated by the linear scratch at the rim of the cylindrical lens employed.

A better method for the determination of astigmatism is by the use of the stenopeic slit, as described under *astigmatism* (*q. v.*), but usually a combination of these methods is employed. Scars on the cornea, conical cornea, synechiæ, etc., interfere greatly with subjective testing of the eye. In the absence of such conditions, a failure to increase the vision by means of lenses indicates some disorder of the eye-ground and necessitates ophthalmoscopic examination.

In examination by means of the trial lenses and test types the general condition of the patient, the presence of noise in the examining or adjacent room, etc., exert considerable influence upon the result, so that more than one examination is necessary for accuracy. The use of the trial lenses should precede any prolonged examination by means of the ophthalmoscope or retinoscope when mydriasis is present, as the continued flashing of bright light into the eye tires the patient, and his answers to the subjective tests are likely to be incoherent and misleading.

An examination should also be made after the effect of the mydriatic has worn off to determine the axis of astigmatism in doubtful cases. Binocular vision with the correcting lenses should be taken for distance and near for comparison with the results obtained under mydriasis in ordering glasses.

Thomson's Refractometer.—The refractometer of Drs. William and Archibald J. Thomson is an ingenious and well-constructed instrument and differs from other instruments used for the same purpose by having an auxiliary eye-piece, which has

signed for the appearance being that the light which entered the eye became absorbed by the retina and choroid. It was reserved for Mr. Cumming, a student at the London Hospital in 1846, to demonstrate that an eye can be visibly illuminated if the observer looks in the same direction as luminous rays entering it from a flame.[1] Shortly afterwards (in 1848) an ophthalmoscope, consisting of a silvered mirror from which a small portion of the silver in the center had been removed, was constructed by Mr. Charles Babbage, the mathematician, who succeeded in looking into the interior of the eye. He showed his instrument to an ophthalmic surgeon, who failed to recognize the importance of the invention, and it was therefore put on one side for a time. But evidently the time was ripe for the production of such an instrument, for in 1851 Professor Helmholtz, of Königsberg, introduced an ophthalmoscope consisting of three disks of highly polished plane glass, placed at such an angle as to act as reflectors of light. Behind them was placed a cell in which concave lenses of varying powers could be inserted. It was at once appreciated by the ophthalmic surgeons who made trial of it, and from that time to the present the ophthalmoscope, in some form or other, has gone on steadily increasing in value and usefulness.

As an instrument of precision in investigating diseases of the deeper structures of the eye it has no equal. It has revolutionized the knowledge, and consequently the treatment, of diseases of those structures, but it may be safely stated that to acquire proficiency in its use no instrument needs more intelligent and persistent practice.

The illumination produced by the reflection of light from the disks of plane glass in Helmholtz's instrument proved to be too feeble for general work, although it should be borne in mind that a feeble illumination, such as that afforded by the Helmholtz instrument, is invaluable in the detection of fine filaments in the media. In 1852 Professor Ruete introduced an ophthalmoscope which consisted of a large concave mirror centrally perforated, with one or more convex lenses interposed between the mirror and the observed eye. By this means an inverted aërial image

[1] "On a Luminous Appearance of the Eye," 1846.

of the ocular fundus was produced, and we are therefore indebted to Ruete not only for the concave mirror, but also for what has since been known as the indirect method of examining the eye.

From that time the material and curvature of the mirror, as well as the arrangement of the lenses used with it for various purposes, have differed considerably, but the ophthalmoscope remains practically the same, and from then till now no new principle has been introduced.

The next important addition was made by Rekoss, an instrument maker, who placed behind Helmholtz's instrument two disks carrying various lenses. The Rekoss disk has since been attached to several other ophthalmoscope mirrors, and when revolved, each of the minus and plus lenses can in turn be brought behind the central aperture or sight hole of the instrument.

A [illegible] improvement was made when the [illegible] was [illegible] the [illegible] ophthalmoscope. [illegible]

Although the mirror of an ophthalmoscope may be plane or concave, the concave surface is usually preferred on account of the concentration of light it produces. Refraction ophthalmoscopes do not differ essentially from those usually employed for examining the fundus oculi.

The Morton and similar instruments used for estimating the refraction are equipped with a greater number of lenses, which can be conveniently and rapidly brought to the sight hole.

The Method of Using the Ophthalmoscope.—When using the ophthalmoscope it should be borne in mind that light thrown into the eye by the mirror of the instrument is returned by the fundus and enters the eye of the observer through the central perforation. No rays will enter an observing eye unless it is situated exactly at the source of light. Hence the necessity of looking through the central perforation of the mirror. A reciprocal relation exists between the object and the image; rays from the image are focused at the object in the same manner as rays from the object meet on the retina and form the image.

In order that the ophthalmoscopic examination be satisfactory it is necessary that the accommodation in the patient's as well as in the observer's eye should be relaxed, and the refraction of both should be emmetropic. Frequently it is necessary to instill a mydriatic to enlarge the pupil. The refraction errors may be corrected by the lenses in the instrument. Cycloplegics may occasionally be used in persons over forty-five years of age, but are very seldom necessary. One drop of a 5-per-cent solution of cocain or euphthalmin may be used in any case without producing any bad effects. The student should examine the eyegrounds in patients under atropin, so that he may familiarize himself with the appearance of the normal fundus, as no great difficulties are encountered in such cases.

The patient should be seated in a dark room, with a light (preferably an Argand burner) placed behind and to one side of the head on a level with the eyes. In examining the right eye the light should be on the right side of the patient, who should be directed to look straight ahead in the distance. The examiner should place the ophthalmoscope close to his own right eye, tilting the mirror toward the light. At a distance of about 15 inches the light should be reflected into the pupil, the red reflex

of which should then be sought. The color is usually red, but may vary in shade considerably, according to the complexion of the patient and the amount of light entering the eye. It depends upon the abundance of choroidal and retinal pigment. The various portions of the eye-ground may be examined by directing the patient to move the eye in various directions.

If the eye-ground presents, at a distance, a homogeneous orange-red color, the eye is normal as regards its refraction, but if any details of the vessels of the fundus are visible, ametropia in some form is present. The patient should be asked to move the head from side to side; any movement of these vessels in the same direction indicates hyperopia, while movement in a direction opposite to that of the head is due to myopia. If the movement is confined to one meridian or is unequal in the principal meridians, astigmatism is present.

Examination by means of the ophthalmoscope at a distance serves also to detect opacities on the cornea or in the media which will appear as dark or black spots in the pupil, well defined by the contrast with the high color of the fundus reflex. These opacities may be fixed or movable, and their location may be determined by the ophthalmoscope as well as by oblique illumination.

The displacement of the spot in its relation to the pupil as the head is moved from side to side is of great aid in locating any opacity. An absence of movement indicates that it is in the plane of the iris. If it moves in a direction opposite to that of the head it is in front of the iris, but if it moves in the same direction as the head it is posterior to the plane of the iris.

The [illegible] as it is moved from side to [illegible]. If the eyeball is moved [illegible] it must be situated [illegible] in the [illegible] spot remains stationary [illegible] of its movement [illegible] posterior to the center [illegible].

Examination of the Fundus.—[illegible] are employed [illegible] the direct and the indirect. [illegible]

cases by the instillation of a drop or two of a 5-per-cent cocain or euphthalmin solution.

The *direct method* gives rise to an erect image that is magnified from 7 to 14 diameters by the cornea and lens, the combined strength of the dioptric system of the eye being equal to that of a convex lens having a focal distance of about 20 mm. The light used in the examination should be placed behind and to one side of the patient's head on a level with the eye. The

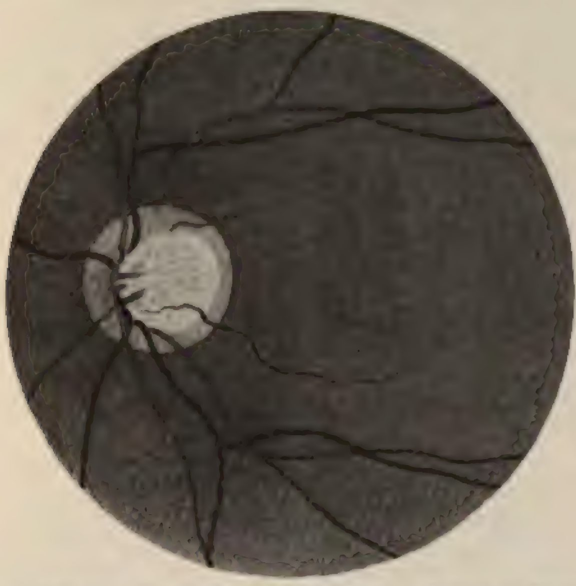


FIG. 231.—NORMAL FUNDUS, SHOWING LARGE CENTRAL PHYSIOLOGIC EXCAVATION. (Elschnig.)

patient is then directed to look straight ahead and the observer seeks the red reflex of the pupil by means of the ophthalmoscope held before his own eye at a short distance from the patient. The examiner approaches the patient until the distance between the instrument and the observed eye is not more than an inch. If any error of refraction is present in either eye, plus or minus lenses should be brought before the sight hole until a clear view of the fundus is obtained. The head of the optic nerve or optic disk should spring immediately into view if the media are clear. The retinal vessels are perhaps seen first and can be traced to the optic disk, which stands out as a circular or oval faintly reddish

spot about the size of a 10-cent piece (sixpence). The real size of the optic nerve head is 1.5 mm. The examination of an aphakic eye will illustrate the effect of the crystalline lens on the magnification of the fundus.

The central artery and vein of the retina emerge from the center of the disk and divide into superior and inferior branches that further subdivide into temporal and nasal branches a short

FIG. 232.—THORNER'S OPHTHALMOSCOPE FOR DEMONSTRATION PURPOSES.

distance from the nerve head. The veins are about one fourth larger than the arteries and darker in color. They may pulsate under normal conditions, but pulsation of the arteries is a symptom of some very serious condition. Bright lines are seen over the middle of the vessels, and this light reflex is of importance, as it may be obscured by some forms of retinal inflammation. An anomaly which occurs frequently is that of a *cilioretinal vessel*, which is seen at the temporal border of the optic disk, arches toward the macular region, and enters the retina. An *optico-*

ciliary vessel does not extend as far as the retina, but is lost to view at the margin of the disk.

Frequently the head of the optic nerve presents a funnel-shaped depression of varying depth due to the separation of the nerve fibers at different levels. This depression is known as the physiologic cup, and is whiter in color than the rest of the disk and never involves the whole nerve head, as does the pathological cup of glaucoma and optic atrophy. Grayish spots are sometimes seen at the bottom of the cup, and represent the openings of the lamina cribrosa. The optic disk is separated from the rest of the eye-ground by a narrow margin made up of two rings. The white circular ring that surrounds the nerve head is the scleral ring, and outside of this is a pigment ring, due to the heaping up of the choroid, known as the choroidal ring. The borders of the disk may be obscured above and below normally, but are particularly so in ametropic individuals.

The retina is transparent except in certain inflammatory conditions, and the color of the fundus is due to the pigment of the choroid, pigment layer of the retina, and the choroidal vessels. It varies with the complexion of the patient, being brighter in persons of fair complexion. The choroidal vessels and pigment are often well marked, particularly at the periphery.

The *macula lutea* is situated about 2 disk diameters to the temporal side of the optic disk, and may be seen by having the patient look at the top of the ophthalmoscopic mirror. It is darker than the rest of the fundus, and no blood-vessels are visible in this region. The position of the *fovea centralis* is frequently marked by one or more bright spots in the center of the macula. By the indirect method the macula may be occasionally seen as a bright spot surrounded by a deeply pigmented area about the size of the optic disk, encircling which is a bright halo.

The *indirect method* produces an image that is inverted, and the fundus is magnified about four diameters. It has the advantage of bringing into view a greater area of the fundus than the other method. The light is placed in the same relation to the patient as in the first method. The observer is seated about one foot from the patient, and throws the light into the eye by means of the ophthalmoscope until the fundus reflex is obtained. A strong convex lens is placed between the eye of the patient and

the instrument, intercepting the rays emerging from the observed eye and focusing them in the air between the lens and ophthalmoscope, thus producing an inverted aërial image.

The results of the ophthalmoscopic examinations vary greatly according to the character of the illumination. Daylight, as pointed out years ago by Jaeger, is probably the best, as the color details of the fundus are retained in every particular. Electric light is next in value, particularly the electric ophthalmoscope, as certain tints of the eye-ground are only partially suppressed. With the ordinary gas flame of the Argand burner the outlines of the retinal structures are well defined, but the color reflex of the fundus is markedly impaired. This was well exemplified recently in a case of intense jaundice at the Medico-Chirurgical Hospital. The skin and mucous membranes were deeply stained yellow. The pupils were dilated with a mydriatic in order to study the eye-grounds carefully. With daylight illumination the ophthalmoscope showed the optic disk to be colored yellow, closely approaching the tint of the conjunctiva and sclera. Below and to the outer side of the disk were ill-defined streaks of a somewhat similar color. The rest of the eye-ground was faintly tinged with yellow. With the electric ophthalmoscope the coloration was, to a great extent, suppressed, but was by no means the color of a normal eye-ground. The disk may be said to be of a reddish yellow. Upon movement of the instrument from side to side, flashes of white light were seen to spring from here, there, and everywhere, but particularly along the lines of the blood-vessels, constituting the so-called watered or shot-silk appearance so frequent in Indian children and those the subject of retinal anes-

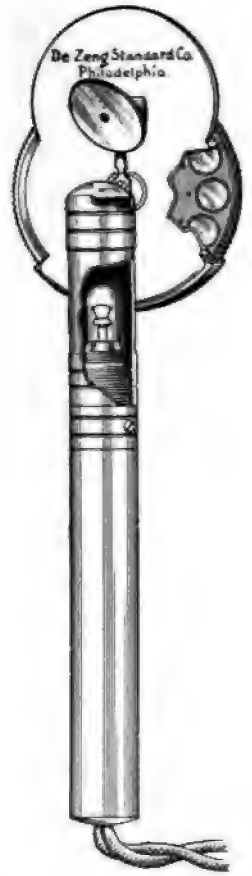


Fig. 233.—De Zeng Electric Ophthalmoscope.

thesia. It was observed that this phenomenon was absent with daylight and gas illumination, and the natural conclusion to be drawn from this is that it is largely due to the character of the illumination. With the gas light, the ophthalmoscope showed no departure in the coloration of the fundus from normal. An observation of the conjunctiva and sclera through the sight hole of the instrument showed the same deficiency in yellow in these structures.

Refraction by the Ophthalmoscope.—Although the macula is the point of most acute vision and a principal focus, it is not selected in estimating the refraction by the ophthalmoscope on account of the difficulty with which it is sometimes located. The head of the optic nerve is prominent in most eyes, and is taken for this purpose. An error, however, may arise from the optic nerve and macula being on different levels, but usually this is slight and may be disregarded.

The ordinary instrument may be used for refraction, but usually the Morton or Fox ophthalmoscope is employed on account of the greater number of lenses it contains and the ease with which they may be brought to the sight hole.

In the *direct method* the accommodation of the patient and that of the examiner should be relaxed for accurate work. The observer's ametropia should be corrected, and the distance between the ophthalmoscope and the eye under examination should be as short as possible. After the fundus comes into view a blood-vessel at the outer margin of the nerve head should be selected. If this appears distinct and becomes blurred by the addition of a S. 0.50 lens, emmetropia is present. If the vessel and margin of the disk are blurred at first and become distinct by the addition of plus lenses hyperopia is present, and is measured by the highest convex glass placed before the sight hole that gives a clear image. In myopia plus lenses further blur the vessels and disk outlines, but minus lenses render them more distinct. The weakest concave lens with which a clear image is obtained indicates the degree of myopia. If the patient or examiner exercises any accommodative effort an additional minus lens will be required to neutralize it, and for this reason the weakest lens is taken as the measurement of the myopia. In astigmatism the vertical and horizontal vessels are seen with unequal dis-

tinctness, and each should be rendered clear separately by the aid of lenses. In calculating the error of ametropia in these cases it should be remembered that the meridian of least refraction is the axis of astigmatism.

The *indirect method* is seldom employed for determining the refraction of the eye, but the size and shape of the inverted image on approaching or withdrawing the lens from the patient's eye will indicate the form of ametropia. In emmetropia no change takes place in the shape and size of the image on withdrawing the lens toward the observer. In hyperopia the shape is unchanged, but the size of the image is diminished on withdrawing the lens. In myopia the image becomes larger and the shape is unaltered under similar conditions. In astigmatism the shape of the image is particularly affected. In simple astigmatism one diameter increases or decreases and the other [illegible]

[illegible]

[illegible]

an examination is about 25 degrees above the horizontal, with the arrowhead pointing toward the lamp. This allows the handle of the instrument to be thrown away from the patient's face and the index wheel can be easily rotated. The advantage of this is obvious.

FIG. 234.—FOX REFRACTION OPHTHALMOSCOPE.

The short focal mirror is used in examination by the direct method to determine the refraction and pathological changes in the cornea, lens, retina, and choroid. In very high myopia the illumination may be fainter than usual, but this may be readily overcome by lessening the distance from the lamp to the mirror. The long focal mirror is employed when the illumination by the short mirror is insufficient, as in very high myopia, in retinoscopy, and in the indirect method.

The diameter of the disk is 42 mm., and has 22 apertures, admitting 10 convex and 11 concave lenses. Added to this is a crescentic segment of a disk with 5 apertures containing 4 lenses. This allows, by combination, 33 convex lenses ranging from 0.5 D. to 22 D. and 42 concave lenses ranging from 0.5 D. to 35 D.

The lenses are brought to the sight hole by an inclosed system of 3 toothed wheels; the first is set on the disk, the second is placed between the disk wheel and the finger wheel, and the third is the lowest, or finger wheel, the milled edge of which projects far enough to allow the index finger to rotate it. Each lens is accurately centered with the sight hole on the mirror by a spring action having its point of pressure on the peripheral edge of the primary disk.

The disk and cap are held in place by screws, which can be removed, allowing the instrument to be taken apart if necessary.

Although of value in refraction, the ophthalmoscope should not replace more accurate methods, such as retinoscopy and the use of the trial lenses.

The ophthalmoscope should no longer be considered as the sole property of the ophthalmologist, for physicians in general practice are by this time alive to the fact that it renders invaluable service in the diagnosis of general diseases. Frequently the characteristic ophthalmic signs which accompany disease of the kidney have been observed by its means when no other symptoms of such disease have been apparent; the discovery of commencing atrophy of the optic nerve has led to the recognition of ataxic symptoms which have been overlooked; the first warning of the presence of an intracranial growth has been given by the sight of a neuritis or a choked disc; and arteriosclerosis has been detected in the retinal vessels before it became apparent elsewhere.

Such signs and warnings are invaluable to the general practitioner, and the time is rapidly approaching when the accomplished physician will feel that it is as incumbent upon him to become proficient in the use of the ophthalmoscope as he is in [illegible] inspection of the visible [illegible] the eye will afford him [illegible] general condition [illegible] advantage [illegible]

Retinoscopy [illegible] —Retinoscopy [illegible] method for the [illegible] illuminated [illegible] and the [illegible] then studied [illegible] children [illegible] performed and [illegible]

[illegible] use of the ophthalmoscope [illegible] and [illegible] has re- [illegible] the light

was darkened. By this observation he anticipated what was later rediscovered by Cuignet, and subsequently developed by Parent.

The principle upon which the shadow test depends consists in finding the point of reversal or the myopic far point. The point in the air in front of the myopic eye at which an inverted image is formed is the far point or point of reversal. In emmetropia and hyperopia it is necessary to add plus lenses to give the eye an artificial far point, for the emmetropic eye is virtually a myopic one with its far point at infinity.

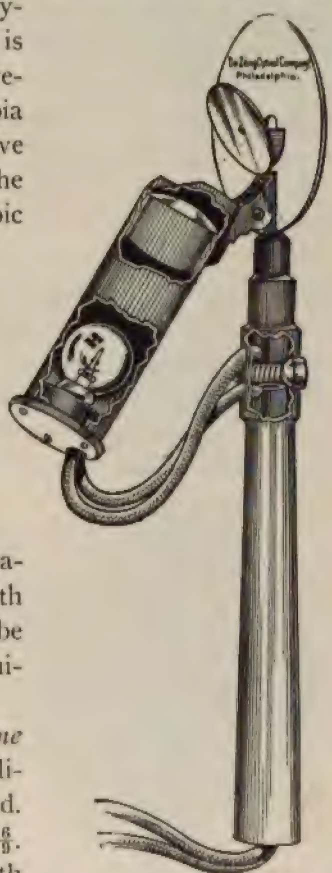


FIG. 235.—DE ZENG'S ELECTRIC RETINOSCOPE.

For the practical application of retinoscopy, cycloplegia should be produced by suitable drugs instilled into the patient's eyes. The examination should take place in a quiet and darkened room. The light should be steady and preferably derived from an Argand gas-burner placed behind and above the patient's head. An asbestos chimney with a large circular opening in front may be placed over the lamp when the illumination is too great or uneven.

The examiner should be seated *one meter* in front of the patient, and ordinarily the plane mirror is employed. He should have vision of more than $\frac{6}{9}$. The diameter of the mirror varies with the personal fancy of the examiner, but for beginners a large mirror is most serviceable, as with it there is no difficulty in detecting the retinal illumination or its movements.

Each eye should be tested separately, and it is best to cover the eye that is not being examined by a blinder, as the reflection from the large retinoscopic mirror may enter this eye and cause needless tiring of the patient. In strabismus it is absolutely necessary to cover the eye that is not under examination; other-

wise the patient will turn the worse eye away from the light when its pupillary area is illuminated.

The examiner should place the retinoscope close to the right eye and view the reflection caused by it through the central aperture of the mirror. The other eye should be kept open. The light is then thrown upon the face of the patient and a red reflex fills the pupillary area. The central portion of the pupillary area is brighter than the periphery, and as the mirror is moved in various directions the illumination moves also, being preceded and followed by a dark shadow. The illumination upon the patient's face always moves in the same direction as that of the mirror, but the direction of the movement of the retinal illumination depends on the presence or absence of ametropia. If the observer is ametropic, the correcting glasses may be worn without influencing the result of the examination in any manner other than to make it less difficult.

The mirror should be rotated slowly from side to side on its long axis. If the plane mirror is employed and the reddish glare that fills the pupil moves in the same direction as that of the mirror, emmetropia, hyperopia, or myopia of less than 1 diopter is present, but if the movement is in the opposite direction myopia of more than 1 diopter is present. The movement of the illumination is reversed if a concave mirror is used. The movement is neutralized by concave or convex lenses placed in a trial frame before the patient's eye. The mirror is then rotated in its horizontal axis, and the movement of the illumination is noticed and neutralized by lenses. The eye may be said to be brought to a condition of emmetropia by the neutralizing lenses when the illumination disappears from all meridians at the same time. If the lenses are added until the movements are reversed the refraction error is slightly overcorrected.

FIG. 136.—RETINOSCOPE.

The rate of movement is of importance, being slower the higher the error. The brightness of the retinal illumination also bears a definite relation to the degree of ametropia. In high degrees the illumination is dull and its edges are indistinct, becoming bright and well defined as the error is neutralized. In emmetropia, the shadow has a more or less crescentic edge, while in astigmatism a straight edge is seen.

To estimate the degree of astigmatism only each of the two principal meridians (always at right angles to each other) should

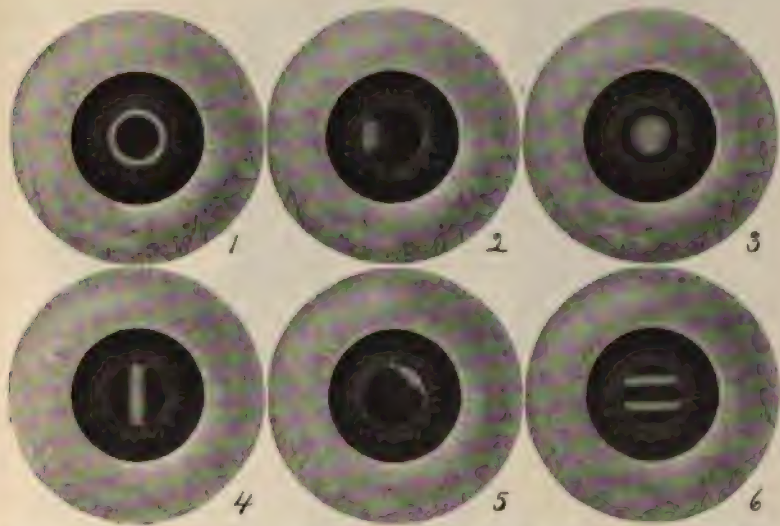


FIG. 237.—THE APPEARANCES OF THE REFLEX IN RETINOSCOPY. (De Zeng.)

1. Positive spherical aberration. 2. Spherical ametropia. 3. Negative spherical aberration. 4. Regular astigmatism with the rules. 5. Oblique astigmatism. 6. Irregular astigmatism, showing scissors movement.

be neutralized separately by means of spherical lenses, as the rays passing through intermediate meridians do not come to a focus. The axis is indicated by the straight edge of the shadow. The degree of ametropia in the meridian of least refraction indicates the spherical lens necessary to correct the spherical defect, myopia or hyperopia. This meridian also corresponds to the axis of astigmatism. The difference between the degree of ametropia in the meridian of greater refraction and that in the meridian of least refraction equals the degree of astigmatism. In irregular astigmatism, conical cornea, etc., the central illumina-

irregularities in the curvature of the cornea. It gives the axis of astigmatism and the quantity present, but fails to indicate the character of the defect whether myopic or hyperopic. It is of value in determining the astigmatic axis in certain cases, but glasses should never be prescribed from its results alone.

The Javal-Schiötz instrument consists essentially of a telescope surrounded by a graduated disk, a double-refracting prism, and an arc bearing two slides or mires. The telescope contains the

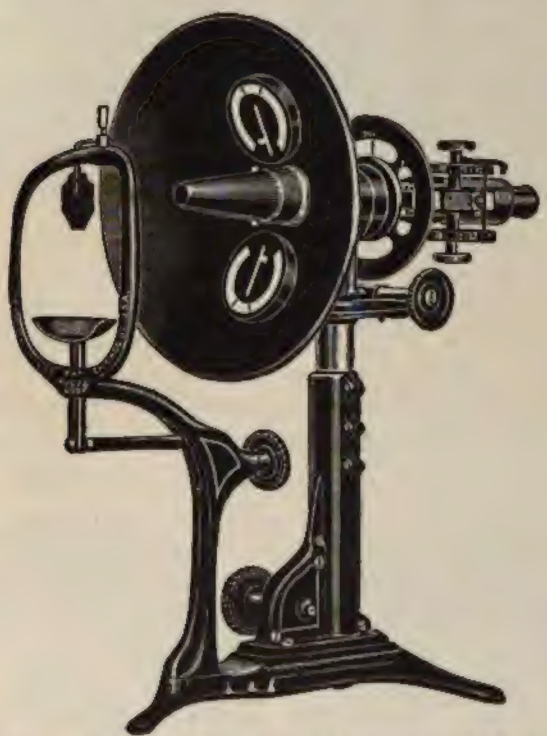


FIG. 240.—CHAMBERS-INSKEEP OPHTHALMOMETER.

This front view presents the stationary mires and head rest. The position of mires as seen on cornea is shown on page 661.

double-refracting prism and is free to rotate on its own axis. An index is attached to the telescope which indicates on a scale on the graduated disk the degree of its rotation. The arc bearing the mires is firmly attached to the telescope and rotates with it. The slides or mires are of the same size, and are usually of white enamel. One is quadrilateral, while the other is cut out on one

cator, giving the radii in millimeters and the equivalent value in diopters and fractions thereof of each curvature of the cornea. In using this instrument only one eye is used at a time, as in

a *b*

FIG. 241 *a* and *b*.—MIRES OF CHAMBERS-INSKEEP OPHTHALMOMETER.

Fig. 241*a* represents the mires as seen on a cornea, widely separated but in perfect alignment, as on a perfect cornea, or on an astigmatic cornea at an exact axis.
Fig. 241*b* shows images as reflected from the cornea when in primary position, and at which you take your first reading from graduated wheel.

other forms of the instrument. After proper adjustment the operator looks through the telescope and perceives the double images of the mires reflected from the cornea. These may be

a *b*

FIG. 242 *a* and *b*.—SHOWING POSITION OF MIRES.

Fig. 242*a* represents the images as seen in a case of astigmatism midway between the two axes.
Fig. 242*b* shows the same case of astigmatism as Fig. 242*a* at exact axis (the secondary position) at which you again take your readings after bringing the images in position to form a perfect cross, as shown in Fig. 241*b*.

blurred, and in such a case the telescope is adjusted until they are brought into focus. The two innermost images are brought near the center of the field by further adjustment, disregarding the outer images. The instrument is then revolved until the axial lines of the images form a continuous straight line. In the absence of corneal astigmatism this will be observed in all meridians. In the presence of such a condition, however, it will be seen in but two meridians, the principal meridians of the cornea. After one axis is obtained and proper adjustment of the mires is made, the refraction of the cornea is read from the scale and noted. The instrument is rotated through 90 degrees, and again adjusted and the refraction of the meridian determined. Two

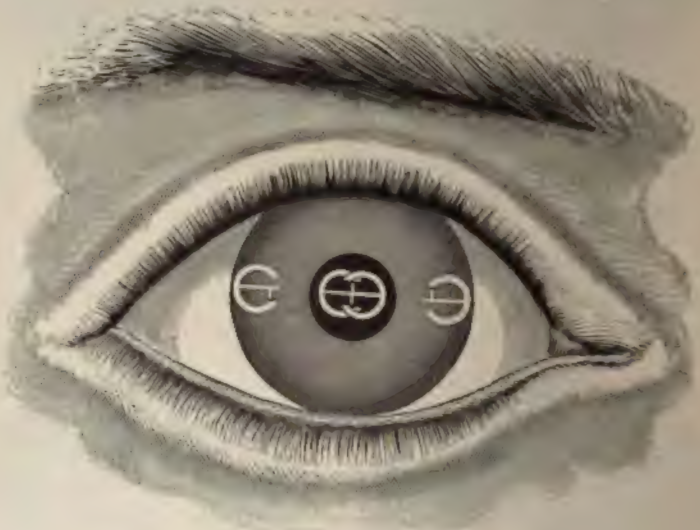


FIG. 243.—SHOWING MIRES ON THE CORNEA.

pointers are employed to indicate the refraction on the scale the interval between which represents the astigmatism. Irregular astigmatism is indicated by the distortion of the circular images of the mires.

The usefulness of the ophthalmometer is greatly limited, and its expense is an additional disadvantage. Used in connection with the other methods for determining astigmatism it is a great aid.

The Sutcliffe Keratometer.—This instrument is described as having one mire, one position, and absolute focus. The single mire is tripled by the optical system and the deflected image

FIG. 244.—SUTCLIFFE KERATOMETER.

shows both the so-called primary and secondary positions in one view. The telescope is not revolved 90 degrees, as in the ophthalmometer, the principal feature of the instrument being the abolition of the secondary position. The *one* mire is made in the form of a circle with four projecting "hooks" (Fig. 245). By means of the optical system the image is tripled and Fig. 246 shows the image as it appears to the operator. The "hooks" are essential parts of the image, and readings are made by observing them.

The mire encircles the telescope near its distal end and is transilluminated by means of 4-candle-power lamps placed in a shield directly behind it.

FIG. 245.—MIRE WITH FOUR PROJECTING HOOKS.

The optical system is made up as follows: A strip of cylinder glass 20 cm. (8 inches) long and $3\frac{1}{2}$ cm. ($\frac{1}{4}$ inch) wide, slightly convex, with the axis parallel to the short edge is divided

Fig. 246.—The Image as it Appears to the Operator.

Fig. 247.—The Arrangement of the Optical System.

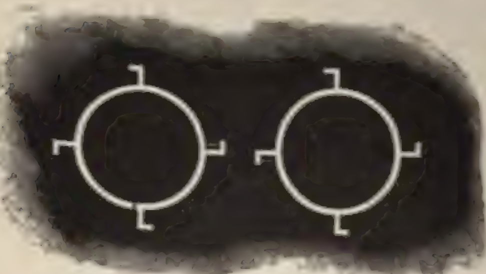


Fig. 248.—The Separation of the Horizontal Circles.

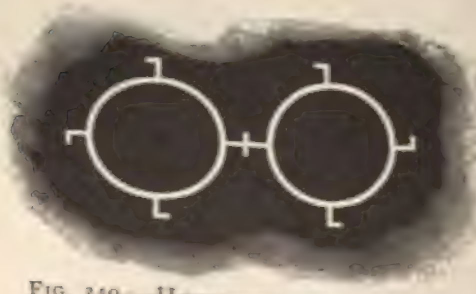


Fig. 249.—Horizontal Circles Correctly Adjusted.

longitudinally into three strips of equal width. A second similar triplet is placed over the first, and of the 9 squares formed by this superimposition, the 4 corner ones are diaphragmed out, leaving 5 openings in the shape of a cross. The system is so placed as to bring the central one of these openings directly in the center of the telescope (Fig. 247).

The central strip in each triplet is adjustable by means of the graduated wheel *h* and the indicator arm *i* respectively. When the cen-

tral lens of the horizontal pair is moved, the upper and corner circles in the image move toward or away from each other, according to the direction in which *i* is rotated. The arm *h* controls the corner and left circles in a similar manner.

FIG. 250.—THE COMPLETE PICTURE, SHOWING BOTH VERTICAL AND HORIZONTAL ADJUSTMENT.

To illustrate: In the image as seen in Fig. 248 the horizontal circles are separated. By rotating the graduated dial *h* to the right or left, as may be necessary, the circles are made to approach each other until the two hooks combine to form a perfect cross as in Fig. 249.

The vertical pair may be similarly adjusted by means of the indicator arm *i*, the resultant picture being shown in Fig. 250.

ORDERING OF GLASSES

In **hyperopia,** as has already been shown, it is necessary to prescribe convex or plus spherical lenses to overcome the defect and to relieve the symptoms of eye-strain. The highest convex glass with which the patient can see distinctly at a distance of 6 meters indicates the degree of hyperopia, but this is not prescribed as a rule. If the patient is to wear glasses constantly a reduction of from 0.25 D. to 0.75 D. should be made, on account of the blurring of distant vision that occurs when full correction is worn, particularly in young adults. If the glasses are prescribed only for close work to relieve eye-strain incident to the patient's occupation, full correction should be ordered. In cases where the symptoms of eye-strain are marked it is frequently necessary to order full correction for constant use, ignoring the distance blurring for a time, and later reducing the strength of the lenses so that vision is distinct for distance as well as for

In **presbyopia** the hyperopia, myopia, and astigmatism should first be corrected to the full extent. The additional convex glasses necessary to correct the presbyopia should be such that distinct vision is obtained at a convenient working distance irrespective of the patient's age. The occupation of the patient should, however, always be taken into consideration. An attempt to follow fixed rules in presbyopia frequently causes unsatisfactory results, so that hard-and-fast rules should be replaced by judgment and the results of experience. In myopia, as has already been stated, presbyopia is retarded, while hyperopia tends to hasten its advancement. It does not take place to the same extent in all hyperopic individuals, and sometimes is unequal in the eyes of the same person. The distance vision should be corrected, and the lenses necessary for the presbyopia should be incorporated with the distance lenses to give satisfactory reading glasses. This may be accomplished by ordering two pairs of glasses, one for distance and the other for close work, in which the presbyopic correction has been added to the first. A more convenient method is to add circular or elliptical convex slips (supplemental lens), equal to presbyopic correction to the distance lenses. The slips are cemented to the distance lenses at their lower portion by Canada balsam and constitute bifocal glasses. They should be made very thin at their upper edges so that the line of junction will be hardly perceptible. Their great advantage is that only one pair of spectacles is necessary. They may also be made by inserting the bifocal slip into a ground-out portion of the distance lens (Borsch), or the distance and reading correction may be ground on or fused in the same lens. In wearing bifocals difficulty may be encountered at first, owing to the line of junction intercepting the central vision. This gives rise to diplopia, but can be readily overcome by proper adjustment of the spectacles. At best they are somewhat annoying for a period of four or five days, but patients soon become accustomed to them.

Formulæ:

℞

O. D. + Sph. 1.25, + cyl. 0.50, ax. 90°;
O. S. + Sph. 1.50, + cyl. 0.25, ax. 90°.
For constant use—distance lenses.

℞

O. D. + Sph. 2.75, + cyl. 0.50, ax. 90°;
O. S. + Sph. 3.00, + cyl. 0.25, ax. 90°.
For close work—reading glasses.

Bifocals are prescribed when it is desirable that the patie wear both distant and reading glasses in the same frame.

Astigmatism requires the wearing of the cylinder obtain during mydriasis. The amount of astigmatism is influenc very little by mydriasis, but the axis is likely to undergo consi erable variation. On this account it is common to examine f astigmatism after the effect of the mydriatic has passed off a to order the cylinder at the axis thus obtained. The real axis astigmatism, however, is the axis demonstrated while the eye at absolute rest, and for this reason the author prefers to ord from the mydriatic examination. When the axes are asymmet cal, or against the rule, the patient often experiences considerat distortion of objects at close range, while distant objects reta their shape and form. This annoying symptom should occasi no alarm to the patient, as it soon disappears with the consta wearing of the lenses. It is always important to have the spe tacles or eye-glasses so fitted that the axes of the lenses corr spond to the axes of the lenses in the trial frame, otherwise d turbing symptoms will arise that may be attributed to inaccura in the examination or in the prescribing of lenses. The patie should be instructed to have the glasses adjusted and centered frequent intervals to avoid this complication.

Formulæ:

℞ *Simple Hyperopic Astigmatism*

O. D. + Cyl. 0.50, ax. 90°;
O. S. + Cyl. 0.75, ax. 105°.

℞ *Simple Myopic Astigmatism*

O. D. — Cyl. 0.50, ax. 90°;
O. S. — Cyl. 0.75, ax. 105°.

℞ *Compound Hyperopic Astigmatism*

O. D. + Sph. 1.25, ⊃ + cyl. 0.50, ax. 90° }
O. S. + Sph. 1.50, ⊃ + cyl. 0.25, ax. 90° } For constant use.

Compound Myopic Astigmatism

℞

O. D. — Sph. 1.25, ⊂⊃ — cyl. 0.50, ax. 180° }
O. S. — Sph. 1.50, ⊂⊃ — cyl. 0.25, ax. 180° } For constant use.

Mixed Astigmatism

℞

O. D. — Sph. 1.00, ⊂⊃ + cyl. 3.00, ax. 90° }
O. S. — Sph. 1.50, ⊂⊃ + cyl. 3.25, ax. 90° } For constant use.

or

℞

O. D. + Sph. 1.00, ⊂⊃ — cyl. 3.00, ax. 180° }
O. S. + Sph. 1.50, ⊂⊃ — cyl. 3.25, ax. 180° } For constant use.

or

℞

O. D. + Cyl. 3.00, ax. 90° ⊂⊃ — cyl. 3.00, ax. 180°; } For
O. S. + Cyl. 3.00, ax. 90° ⊂⊃ — cyl. 3.00, ax. 180°. } constant use.

It is always very important in ordering cylindrical lenses to indicate the axis of the lens, to prevent unnecessary embarrassment.

Prisms are often ordered, and the strength necessary may be placed before only one eye or may be divided between both eyes. The degree of the prisms and the situation of the base should always be indicated. Decentering of lenses may be employed in place of prisms.

Decentering of Lenses.—If prismatic effect is desired without prescribing a lens and a prism, the lens can be decentered. Such lenses are sometimes known as *primospheres.* The rule is: For every centimeter of decentering there will result as many prism diopters as there are diopters in the meridian of the correcting lens. On account of the size of the rough ground lenses it is often not possible to decenter more than 1 cm., and in lenses of low power it is better to order the prisms in these cases than to obtain the primastic effect by decentering.

A spherical convex lens decentered in, gives a prism base out. A concave spherical lens decentered in, gives a prism base in. The following table, devised by Dr. Edward Jackson, of Denver,

shows the decentering of lenses for prismatic effects, with glass having an index of refraction of about 1.54:[1]

Power of Lens in Diopters.	To obtain 1° Prism.	To obtain 2° Prism.	To obtain 3° Prism.	To obtain 4° Prism.	To obtain 5° Prism.	To obtain 6° Prism.	To obtain 8° Prism.	[illegible]
	Decenter mm.	Decenter mm.	Decenter mm.	Decenter mm.	Decenter mm.	Decenter mm.	Decenter mm.	Decenter mm.
1 D.	9.4	18.8	28.3	37.7	47.2	56.5	75.8	[illegible]
2	4.7	9.4	14.1	18.8	23.6	28.2	37.0	[illegible]
3	3.1	6.3	9.4	12.6	15.7	18.8	25.3	[illegible]
4	2.3	4.7	7.1	9.4	11.8	14.1	18.9	[illegible]
5	1.9	3.8	5.7	7.5	9.4	11.3	15.2	[illegible]
6	1.6	3.1	4.7	6.3	7.9	9.4	12.6	[illegible]
7	1.3	2.7	4.	5.4	6.7	8.1	10.8	[illegible]
8	1.2	2.3	3.5	4.7	5.9	7.1	9.5	[illegible]
9	1.	2.1	3.1	4.2	5.2	6.3	8.4	[illegible]
10	.9	1.9	2.8	3.8	4.7	5.6	7.6	[illegible]
11	.9	1.7	2.6	3.5	4.3	5.1	6.9	[illegible]
12	.8	1.6	2.4	3.1	3.9	4.7	6.3	[illegible]
13	.7	1.4	2.2	2.9	3.6	4.3	5.8	[illegible]
14	.7	1.3	2.	2.7	3.4	4.	5.4	[illegible]
15	.6	1.3	1.9	2.5	3.1	3.8	5.1	[illegible]
16	.6	1.2	1.8	2.4	3.	3.5	4.7	[illegible]
17	.6	1.1	1.7	2.2	[illegible]	3.4	4.5	[illegible]
18	.5	1.	1.6	2.1	[illegible]	3.1	4.2	[illegible]
19	.5	1.	[illegible]	2.	2.5	3.	4.	[illegible]
20	.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Spectacle frames should be prescribed as often as possible, and the frames should be sufficiently strong to maintain perfect adjustment. If plane spherical lenses are ordered or if the nose be so shaped as to hold them straight, there is no objection to eye-glasses, but usually such is not the case, and the focus of the lenses changes every time they are placed before the eyes. The size of the lens or "eye" should be such as to afford protection to the eye and should be of the same shape. The centers should correspond with the pupillary centers and should be perpendicular or very slightly inclined to the line of vision. The eyelashes of the patient should not come in contact with the lenses. For close work the inclination should be greater than this to avoid [illegible]. All these points should be carefully examined and the glasses neutralized before the patient is discharged. The methods of neutralization of lenses have already been described in a previous chapter.

Although the fitting of spectacle frames is the province of the [illegible] so placed that it is necessary

[1] [illegible]

for him to take the measurements. The pupillary distance should first be taken by measuring the distance in millimeters from the outer edge of one pupil to the inner edge of the other pupil. This serves to indicate the positions of the center of the lenses.

The temple or side pieces should be measured from the top of the ear to the plane of the lenses or to a horizontal line just beyond the eyelashes. The nose-piece or bridge is the most important; it may be measured by selecting from a number of frames one which may be molded to fit the nose and measuring the bridge of this frame, or a piece of lead wire may be molded to the nose at the position the bridge will occupy. The height of the bridge is the distance from its top to a horizontal line passing through the pupillary centers or centers of the lenses. The distance between the lower arms equals the width of the nose and also the bridge. The relation of the bridge to the plane of the lenses, whether inside or outside, and the distance, should also be taken. The shape of the bridge is indicated by the shape of the lead wire. The size of the lens, when not otherwise indicated, is taken as "O," the size of the average eye, "OO" and "OOO" being the next larger, and 1 eye and 2 eye, the next smaller, the latter size being prescribed for children. A prescription giving the dimensions just stated can be filled by any optician, but some skill and ingenuity is yet required to fit the glasses before the eyes satisfactorily.

The care of spectacles requires a few words, as the work of a skilled oculist may be more or less disturbed by their improper use. The hooks back of the ears should be removed first in taking off spectacles to avoid straining the delicate hinges. They should be folded up as little as possible, and not allowed to rest face down, or the polish will be destroyed in a short time. Ordinary water or ammonia water may be used to cleanse the glasses. Under no circumstances should alcohol, heat or turpentine be employed in cleansing bifocal glasses, as the cemented slips will separate. The end-piece and not the bridge should be held during such procedure.

CHAPTER XXIII

THE EXTRA-OCULAR MUSCLES

GENERAL CONSIDERATIONS

THE extra-ocular muscles may be divided into two sets, t *palpebral* and the *orbital*.

The palpebral muscles include the *orbicularis palpebrar* the *tendo-palpebrarum*, the *corrugator supercilii*, and the *tens tarsi*. The orbicularis palpebrarum is a circular muscle of sphin ter character, situated at the circumference of the orbit and su rounding the eyelids. The fibers are concentrically arranged a

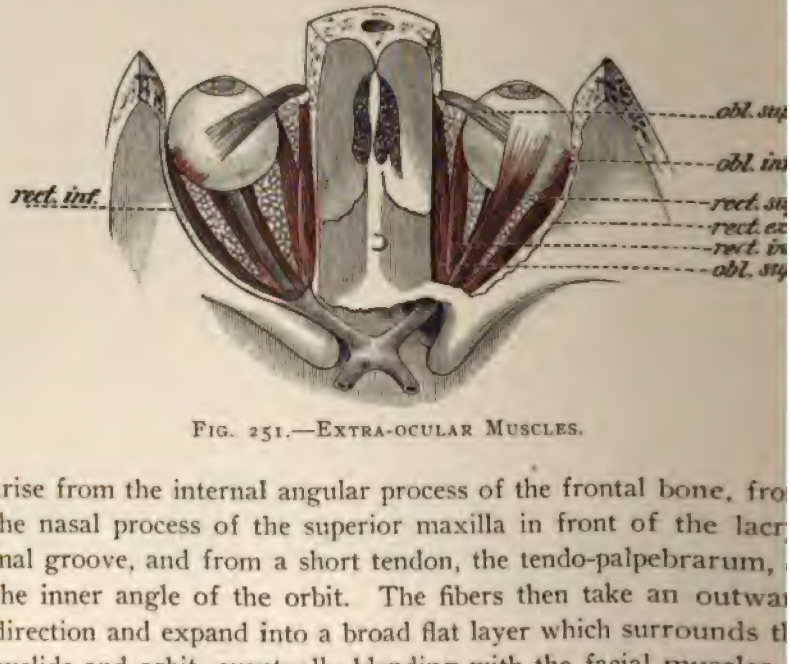


FIG. 251.—EXTRA-OCULAR MUSCLES.

arise from the internal angular process of the frontal bone, fro the nasal process of the superior maxilla in front of the lacr mal groove, and from a short tendon, the tendo-palpebrarum, the inner angle of the orbit. The fibers then take an outwa direction and expand into a broad flat layer which surrounds t eyelids and orbit, eventually blending with the facial muscles this vicinity. The function of the orbicularis is to close the ey lids, and may be voluntary or involuntary as in blepharospas

The **tendo-palpebrarum** or **tendo-oculi** is an exceedingly short and narrow muscle situated at the inner angle of the orbit attached to the nasal process of the superior maxilla, anterior to the groove for the nasal duct. It crosses the lacrymal sac and divides into two slips, each of which is attached to the inner extremity of the corresponding tarsal plate. As the lacrymal sac is crossed an aponeurosis is given off from the posterior portion that expands over the sac and is attached to the ridge on the lacrymal bone. This muscle gives attachment to the orbicularis palpebrarum and the tarsal plate and serves to suck the tears into the lacrymal sac. As the eyelids are closed the tendo-oculi is rendered tense, and the wall of the lacrymal sac is drawn outward and forward. A vacuum is formed, which is readily overcome by the external pressure forcing the tears into the sac.

The **corrugator supercilii** is a small pyramidal muscle placed at the inner extremity of the eyebrow. It takes its origin from the superciliary ridge and is inserted into the under surface of the orbicularis. It serves to produce frowning by drawing the eyebrow downward and inward.

The **tensor tarsi,** or Horner's muscle, is also situated at the inner side of the orbit, but behind the tendo-oculi. At its origin it is attached to the crest of the orbital surface of the lacrymal bone, and afterwards divides into two slips which cover the lacrymal canal and are inserted into the tarsal plates internal to the puncta lacrymalia. It serves to draw the eyelids and extremities of the lacrymal canals inward and to compress them against the surface of the eye, thus placing them in a position to receive the tears.

This group of muscles is supplied by the *facial nerve*, injury or disease of which results in loss of function in the muscles thus supplied. This is illustrated by the fact that, frequently, oculists are consulted regarding profuse and continued lacrymation which is unconnected with ocular or lacrymal disease, but has its cause in a mild attack of Bell's palsy. This set of muscles is also of importance on account of its relations to plastic operations upon the eyelids and operations upon the lacrymal apparatus.

The orbital muscles consist of the *levator palpebræ supe-*

rioris, the *superior rectus*, the *inferior rectus*, the *internal rectus*, the *external rectus*, the *superior oblique*, and the *inferior oblique*.

The **levator palpebræ superioris** arises from the under surface of the lesser wing of the sphenoid above and in front of the optic foramen, and is inserted into the anterior surface of the superior tarsal plate. A thin aponeurosis of this muscle is inserted into the skin of the eyelid. Its function is to elevate the

FIG. 252.—RECTI MUSCLES.

lid, and is the direct antagonist of the orbicularis muscle. It is supplied by the third nerve, injury or disease of the filament sent to the muscle inducing loss of function or drooping of the upper lid (ptosis).

The **superior rectus** is the thinnest and narrowest of the straight muscles. It takes its origin from the upper margin of the optic foramen and fibrous sheath of the optic nerve, and is

inserted into the sclera by a tendinous expansion about 7.54 mm. from the corneal limbus.

The **inferior rectus** arises from a tendon common to it and the internal rectus, which is attached to the lower and inner part of the optic foramen, and from the fibrous sheath of the optic foramen. It passes along the floor of the orbit and is inserted into sclera about 7.0 mm. from the corneal margin.

The **internal rectus** arises from a common tendon at the posterior portion of the orbit. It passes along the inner wall of the orbit and is inserted into the sclera by a tendinous expansion about 6.91 mm. from the corneo-scleral junction.

The **external rectus** arises from two heads, one from the common tendon of the internal and inferior rectus, the other from the upper margin of the optic foramen. These unite to form the body of the muscle, which follows the external wall of the orbit and is inserted into the sclera about 7.85 mm. from the corneal limbus.

The **superior oblique** takes its origin from the lesser wing of the sphenoid at the upper margin of the optic foramen. It passes forward along the inner wall of the orbit to the inner angle, where it terminates in a rounded tendon. This tendon passes to a pulley-like process beneath the internal angular process of the frontal bone. The tendon is now reflected backward and inserted into the outer and posterior surface of the sclera midway between the cornea and entrance of the optic nerve, about 17.9 mm. distance from the corneal limbus.

The **inferior oblique** arises from a depression in the superior maxillary bone in the anterior third of the orbit. Its course is outward, backward, and upward, and is inserted into the outer portion of the sclera about 17 mm. from the corneal margin and 5.5 mm. from the entrance of the optic nerve.

The function of the muscles which are inserted into the sclera is to rotate the eyeball in various directions. The external rectus and the two oblique are abductors and rotate the eye outward, while the internal, inferior, and superior recti are adductors and turn the eyeball inward. The four recti, acting singly, will turn the eye in the direction indicated by their names. Circumduction of the eyeball is produced by the alternate action of the four recti muscles. The action of two contiguous recti of one eye

carries the eye in the diagonal of their direction: upward and inward, upward and outward, downward and inward, or downward and outward. The superior rectus and inferior oblique are elevators of the eyeball, while the inferior rectus and superior oblique serve to turn the globe downward. The superior oblique and superior rectus also cause internal rotation of the upper part of the eye, while the lower portion is turned inward by the inferior oblique and inferior rectus. The actions of these muscles are at all times harmonious and reciprocal, and excessive functional activity on the part of the abductors or adductors is

FIG. [illegible].—NORMAL FIELD OF FIXATION. (After [illegible].)

restricted by prolongations from Tenon's capsule, known as check ligaments.

The third or oculomotor nerve supplies all these [illegible] muscles with the exception of the superior oblique and external rectus. The superior oblique receives its innervation from the fourth cranial nerve, and the external rectus is supplied by the sixth or abducens nerve. The centers which control the movements of the individual muscles correspond to [illegible] area near the facial center in the brain and to the nuclei of origin of the nerves that supply the muscles.

The Field of Fixation.—The greatest extent of movement of the eyes is downward and the least is upward. The field of fixation includes all points toward which both eyes can be directed without changing the position of the head. In the normal eye it extends about 45 degrees upward, inward, and outward, and about 55 degrees downward.

COÖRDINATION AND INCOÖRDINATION

Every movement of one eye is accompanied by a corresponding movement in the other eye except in rare cases, where normally one eye may be moved independent of the other. These simultaneous movements may occur in the same direction, causing the visual lines to be parallel or in such direction that the visual lines converge. The object of this coördination of the muscles of both eyes is to direct the visual axes so that the two images of any object may fall on corresponding portions of the two retinæ. This causes effacement of the normal blind spots, and the two images are readily fused into one.

A special center in the brain governs this coördination of the ocular muscles. It is located in the nates of the corpora quadrigemina. Stimulation of the right side gives rise to movements of both eyes to the left, while stimulation of the left side causes movement to the right. If the stimulation is applied to the posterior portion in the median line, convergence is brought about, and stimulation of the anterior portion in the middle line causes an upward movement with a return to parallelism, both movements being accompanied by the usual associated movements of the pupil.

The perfect coördination of the ocular muscles with binocular vision is also known as muscle equilibrium or balance. Its maintenance depends upon the condition and strength of the muscles as well as upon the nerves and nerve centers. A departure from the normal is frequently overcome by increased innervation, so that equilibrium and binocular vision are maintained, but symptoms belonging to the group known as muscular asthenopia occur as a result.

Unilateral voluntary movements of the ocular muscles, although very rare, are occasionally seen. A case recently came

under the observation of the author where the patient, a young man, was able to rotate one eye inward at will, similar as in the act of extreme convergence. There was no associated voluntary nystagmus. This extreme volitional innervation of the muscle was checked by a complete tenotomy of the internal rectus muscle of the affected eye. The vision with proper correcting lenses was normal.

Perfect binocular single vision, or the blending of two images into one, occurs only when the two images fall on corresponding points of the two retinæ. These points are as follows: The upper portion of the retina of the right eye corresponds to the upper portion of the same structure in the left eye, and the lower portion of the right retina also corresponds to that of the left, but the nasal portion of the retina of the left eye corresponds to the temporal of the right eye, and the temporal side of the left corresponds to the nasal side of the right eye. Any disturbance of the harmonious action of the ocular muscles causes the images to be formed on noncorresponding points, and binocular vision is destroyed. This also occasionally occurs after cataract extraction due to malposition of the pupil. Diplopia does not always occur because the image formed in the [illegible]

power of abduction is the power of rotating the eyes outward to overcome diplopia produced by prisms, bases in. The power of rotating the eyes in the horizontal meridian, so that the effect of prisms, bases up or down, is overcome, is known as sursumduction. The strength of the highest prism that can be overcome maintaining perfect binocular vision indicates the power of the muscles.

Incoördination of the extra-ocular muscles arises from a great variety of causes, and is known as muscle imbalance, disturbance of equilibrium, and functional anomalies of the extra-ocular muscles. The descriptive nomenclature of the various forms of incoördination generally accepted was suggested by Dr. George T. Stevens, of New York.

For latent squint, or the disturbance usually of slight extent and readily overcome:

Orthophoria—perfect muscle balance or coördination.

Heterophoria—disturbances of muscle equilibrium or incoordination.

Hyperphoria—a tendency toward upward deviation of one eye.

Esophoria—a tendency toward inward deviation.

Exophoria—a tendency toward outward deviation.

Hyperesophoria—a combination of a tendency of one eye to deviate upward and inward or of its fellow to deviate downward and inward.

Hyperexophoria—a tendency toward upward and outward deviation of one eye or of downward and outward deviation of its fellow.

When the deviation of the visual axis is absolute and perfect binocular fixation cannot be effected, the following terms are employed:

Orthotropia—perfect binocular fixation.

Heterotropia—deviation from parallelism, or squint.

Esotropia—inward deviation, or convergent squint.

Exotropia—outward deviation, or divergent squint.

Hypertropia—deviation of one eye upward and of the other downward.

Combinations of these deviations may also occur.

TESTS FOR INCOÖRDINATION OF THE EXTRA-OCULAR MUSCLES

Diplopia.—All these tests depend upon the detection of diplopia and upon the ascertaining which eye fails to "fix" when the patient looks at an object. Two images are formed, and their position indicates the character of the incoördination. If one eye is turned in, the false image will appear to be situated on the same side of the object as the eye. This is known as *homonymous diplopia.* If the eye turns outward the false image appears to be on the opposite side. This is called *heteronymous* or *crossed diplopia.* Disturbances of the vertical muscle balance are always divergent in character and crossed diplopia is the result. The eye that deviates upward is taken as the defective or hyperopic eye, and its image is below that of the fixed eye.

In testing the muscles for functional disturbance the strength of each group should first be taken. This is known as muscle phorometry. The patient is seated at a distance of 6 meters from a steady point of light or suitable test card. The abductors should be tested by placing prisms, bases in, in a trial frame before the patient's eye until fusion of the two images thus produced is no longer possible. The highest prism overcome indicates the strength of the abductor muscles, and is usually 6 to 8 degrees. To measure adduction the prisms are placed bases out. Normally, the highest prism overcome varies from 20 to 30 degrees. Supraduction and infraduction are determined by placing the bases down or up. They are usually of equal strength, and are seldom more than 2 or 3 degrees.

FIG. 254.—BINOCULAR SINGLE VISION.

The excursions of the eye should always be observed by requesting the patient to fix the gaze upon a pencil or similar object held about 13 inches from the eye. The object is then moved in

various directions, and the movements of the eye in following the object should be carefully noticed. Under ordinary conditions the inward movement is about 45 degrees, the outward movement 45 to 50 degrees, the upward movement about 40 degrees, and the downward movement about 60 degrees.

Another test easily performed is the *cover test.* One eye should be covered while the other is fixed upon some object held at about 13 inches distance. If on removal of the cover the non-fixing eye moves inward to fix upon the object, outward deviation was present while the eye was covered. If the eye just uncovered moves outward, inward deviation was present. If the released eye turns upward in fixing on the object a downward deviation was present; a reversal of the movement indicates an upward deviation. As the eye is at rest during the period in which it is covered, the deviation it then undergoes indicates the deviation toward which it tends when not excessively stimulated for binocular fixation.

Insufficiency of the ocular muscles may also be demonstrated by bringing the object, on which the eyes are fixed, to within 4 or 5 inches of the patient. As accommodation increases convergence should increase proportionately, but if the internal muscles are too weak or the external muscles are too strong this will not occur.

Sometimes the placing of a colored glass before the eye will bring out the diplopia present and serve to locate the position of the images. If the colored glass is placed before the left eye and the colored image is to the left of the true image, homonymous diplopia is present, and the condition is that of esophoria or internal deviation. If the colored image is to the right of the true image, crossed diplopia is present, and the muscle condition is that of exophoria or outward deviation.

FIG. 255.—HOMONYMOUS DOUBLE IMAGES.

Monocular Diplopia.—This is believed to be due to several causes, such as astigmatism, and in that form which occurs as an irregular variety in the lenticular changes of incipient cataract, hysteria, corneal opacities, organic disease of the brain or meninges associated with paralysis of the sixth cranial nerve, dislocation of the crystalline lens, malingering. As described by Verhoeff, the condition can be produced as follows:

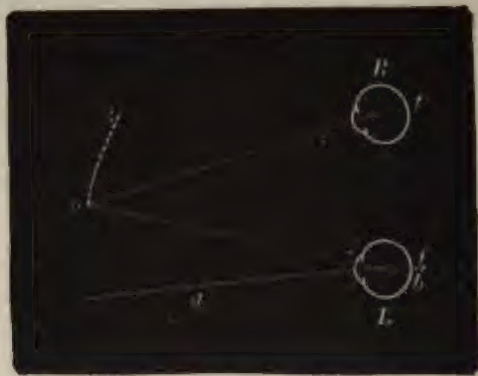


FIG. 256.—CROSSED DOUBLE IMAGES.

"The phenomenon may be well seen by most persons by viewing a narrow black line at a distance of about 30 cm. On relaxing the accommodation the line will be seen to break up into two. More striking, however, is the diplopia which may be produced by viewing the ordinary test type at 6 M. through a concave cylindrical lens of 1.50 D. or 2 D. placed horizontal, or better still, through a stenopeic slit placed vertical and combined with − 2 D. S. If care is taken to keep the accommodation re-

FIG. 257.—DOUBLE IMAGES, WITH DIFFERENCE IN LEVEL.

laxed, the smaller letters will be seen in double rows one above the other, and entirely separated from each other. The larger letters will be seen to be double, but the doubling is not sufficient to cause complete separation."

Maddox's Test.—Another convenient test is the Maddox rod, which consists of a glass rod or series of glass rods, which if placed in a frame before the eye will distort a point of light at 6 meters distance into a streak of light running at a right angle to its long axis. Its effect is that of a high cylinder, and may be replaced by one. The glass is sometimes tinted. For the practical application of this test the patient should be seated in a dark room about 6 meters distance from a small, steady point of light. The disk in which the rod is mounted should be placed before the left eye. A blank disk should be placed before the right eye. The rod should be placed so that it is exactly in front of the pupil, and its long axis should be horizontal at first. As the patient looks toward the light a vertical streak of light is seen. The rod is then covered and the right eye is uncovered, so that the natural point of light may be seen. The cover is removed from the rod, and if there is perfect muscle equilibrium (orthophoria) the streak will be seen to pass directly *through* the light. If the streak is to the *left* of the light, esophoria is present; but if the streak is to the *right* of the light, exophoria is present. The degree of insufficiency may be measured by the strength of the prism necessary to bring the streak directly through the light. In the case of esophoria, the degree of insufficiency is measured by the strength of a prism, base out, before the left eye, which will cause the streak to pass through the light. In the case of exophoria it is measured with prisms, bases in. In hyperphoria, according to the variety, the insufficiency is ascertained with prisms, bases up or bases down. The rotary prism of Crété or that of Risley is best adapted for this purpose.

Fig. 258.—Maddox Rod.

To test for hyperphoria the disk containing the rod is rotated until the rod is vertical. This causes the streak to appear hori-

zontal. If the vertical muscles are perfectly balanced the
will pass through the center of the light, otherwise it w
above or below it. If the streak i
the light, the left eye turns down
if it is below, the left eye tu
ward. The prism necessary to b
streak through the light indicates
gree of hyperphoria, but the ey
and the position of the prism
should always be specified in not
result.

A more satisfactory test is
which diplopia is produced by
prisms before the eyes. It may
formed by placing a prism of
grees, base up or down, befo
eye and a tinted glass befo
other. Vertical diplopia is the
duced. If orthophoria is prese
images will be directly above
other, so that a vertical line
from one will pass directly throu
other. If the prism is placed,
down, before the right eye, the
image will belong to the right ey
if this image is to the right of the
image inward
deviation of
the visual axes is indicated. The
prism, placed base out before the
eye, that brings the two images in
line indicates the degree of esophoria.
If the upper image is to the left of
the lower, exophoria is present and
may be measured by the prism, base
in, which brings them to the normal
position.

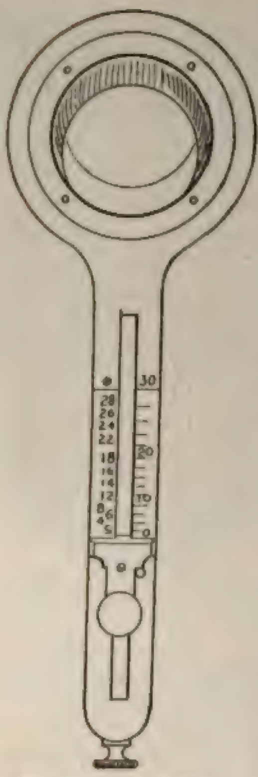


FIG. 259. — CRÉTÉ'S ROTARY PRISM.

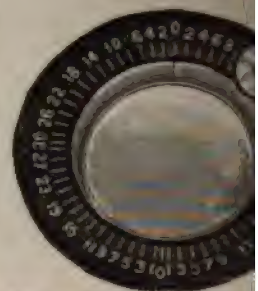
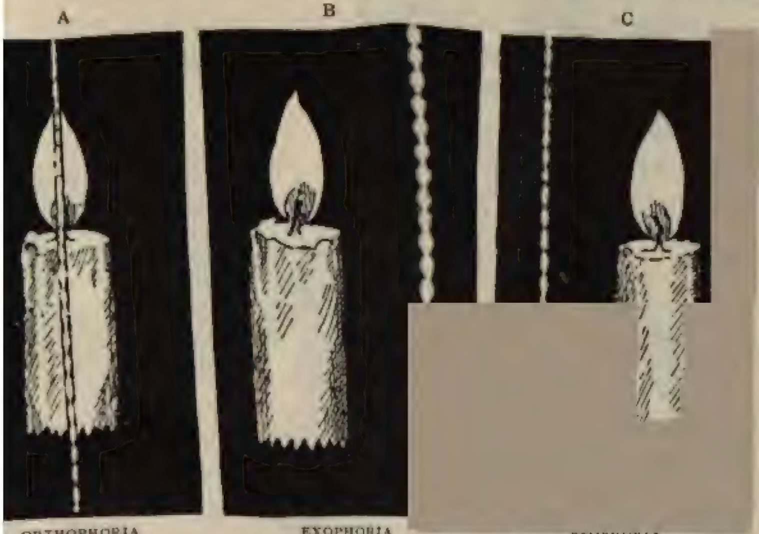


FIG. 260.—RISLEY P

In determining the insufficiency of the vertical muscles,
eral diplopia should be produced by placing a high prism 1c

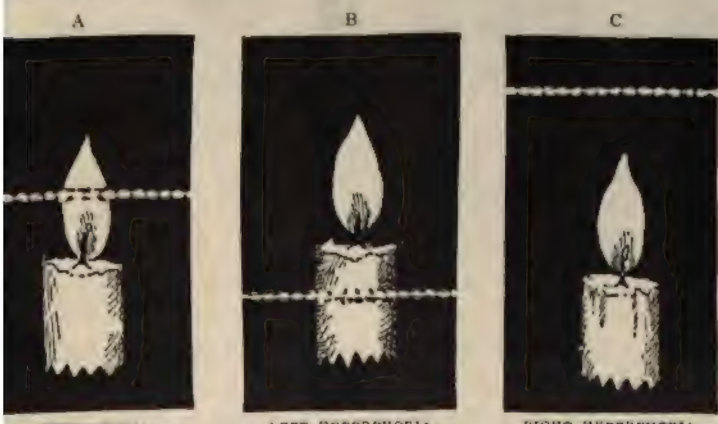
base in, before either eye, preferably the right. Ortho-
is indicated by the two images thus produced being on



Prism base in to correct. (See Fig. 263.) *Prism base out to correct.*

261.—MADDOX ROD TEST FOR LATERAL DEVIATION WITH ROD BEFORE THE LEFT EYE.

line passes through the flame—Orthophoria; *B*, the line passes to the right of the flame—atent Divergence or Exophoria; *C*, the line passes to the left of the flame—Latent Con-ergence or Esophoria.



Prism base down left eye to correct. *Prism base up left eye to correct.*

262.—MADDOX ROD TEST FOR HORIZONTAL DEVIATION WITH ROD BEFORE THE LEFT EYE.

line passes through the flame—Orthophoria; *B*, the line passes below the flame—Left Hyperphoria; *C*, the line passes above the flame—Right Hyperphoria.

the same horizontal plane. If the image of the right eye is h
than that of the left, the visual axis of the right eye devi
upward, and the degree is measured by the prism placed, b
down, before the right eye, or base up, before the left eye t
brings the images to their normal relation. This test fail
determine which eye is at fault in insufficiency of the vertical muscles.

FIG. 263.—EXOPHORIA.
Showing the effect of a prism base in throwing the line *A-A* to *B-B*.

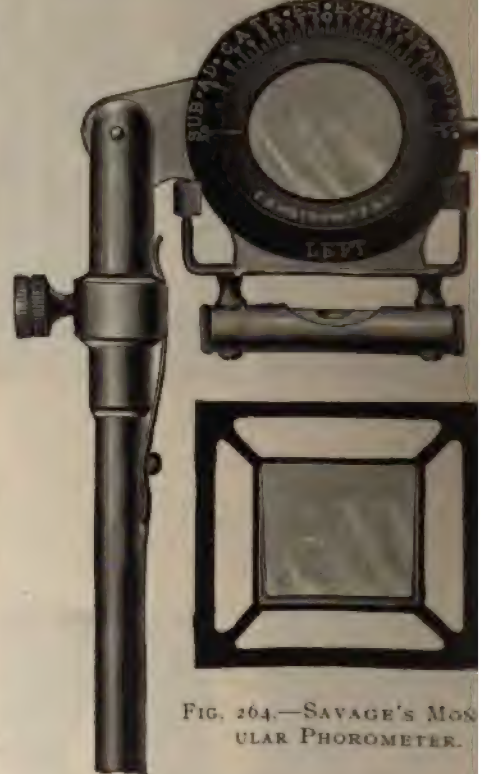


FIG. 264.—SAVAGE'S MON
ULAR PHOROMETER.

Savage's Monocular Phorometer.—This instrument (Fig. 2
is designed for the determination and measurement of in
ficiencies of the various ocular muscles and is based on the p
ciple that the image in one eye throughout every test shal
undisturbed. It consists principally of a rotary variable pr
correctly marked in degrees and lettered to show the var
conditions of muscular imbalance, such as exophoria, esopho
hyperphoria, etc., etc. On each side of the rotary prism are c
in one of which, toward the patient's face, is to be placed the
placing prism for causing diplopia. These prisms are moun

in square cells for securing accurate position at either 90 degrees or 180 degrees. The instrument has a spirit level and a leveling screw. The prism is reversible for either eye.

Stevens' phorometer is also of great value in determining disturbances of muscle equilibrium. It consists of two 4-degree prisms mounted in a frame which should be held about 3½ inches from the eye. The prisms are so placed that they can be rotated, and the character of the defect as well as its degree is indicated on a graduated scale at the periphery of the frame. The patient is directed to gaze upon a light at 6 meters distance through the prisms, which immediately give rise to diplopia. If the indicator points to the zero mark on the scale, orthophoria is present as

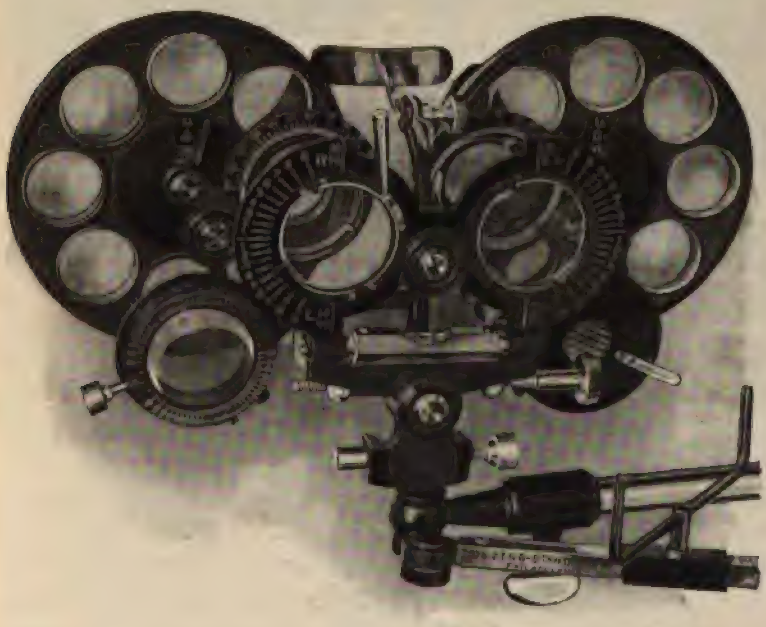


FIG. 265.—MODERN OPTOMETER AND PHOROMETER. (De Zeng.)

regards the set of muscles being examined, and the two lights will be on the same plane. If the lights are not on the same plane, the prisms should be rotated until such is the case, the index now pointing to the degree of muscle disturbance. This instrument is inapplicable in very high degrees of heterophoria.

Owing to the confusion in the patient's mind which the lig
ordinarily employed, sometimes induces, the author has desig
a chart (Fig. 269) upon which it is very easy for the patient
fix his attention. It consists essentially of a dial, with a numb

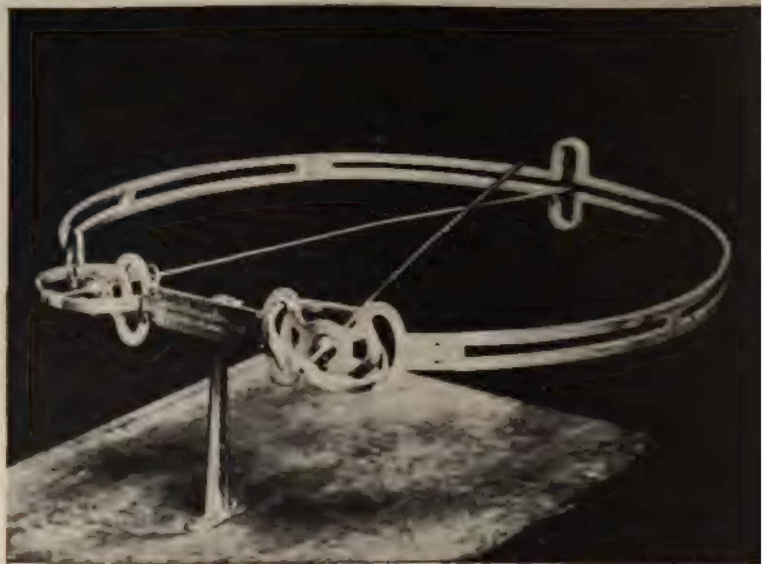


FIG. 266.—SAVAGE'S MUSCLE INDICATOR.

of radii, from the periphery of which four lines extend,
vertical and two horizontal, corresponding to the principal di
eters of the dial. The card containing the dial is placed
meters distance from the patient and is properly illumina
The phorometer is then placed before the eyes and two dials
seen. If the horizontal lines coincide and form one straight
and the indicator points to zero on the scale, orthophoria is p
ent. If the two dials are side by side and their horizontal line
not coincide, right or left hyperphoria is present. The pri
should be rotated until the relative positions of the two
are the same as in orthophoria. The indicator on the phor
eter shows the prismatic effect necessary to accomplish thi
the degree of hyperphoria. If the images are one above
other, and the vertical lines do not coincide, esophoria or
phoria is present. The prisms are again rotated until the ve
cal lines form a long straight line. The degree and chara

of the lateral insufficiency can then be read from the scale on the phorometer.

Savage's Muscle Indicator.—A very ingenious instrument is the "muscle indicator" (Fig. 266) devised by Dr. G. C. Savage, of Nashville, Tenn. Some of Dr. Savage's views on ocular rotations are clearly outlined in the *Ophthalmic Record* for March, 1907, and December, 1907, and illustrated by the mechanism of his muscle indicator. In the latter paper Dr. Savage lays down the following law of both binocular rest and motion:

"*The ocular muscles must so relate the two eyes that the two visual axes and the two horizontal retinal meridians shall always lie in the plane of the primary isogonal circle, and that the two visual axes shall intersect at some point on this circle, in the interest of both binocular single vision and correct orientation.*"

Rotary prisms may be employed in conjunction with the Maddox rod test to ascertain the degree of heterophoria. Risley's rotary prism is probably most commonly used in this connection. The principle is the same in all forms of this apparatus. It consists of two superimposed prisms of 15 degrees each, mounted in a milled-edge cell. A graduated scale is marked on the rim of the cell and a linear scratch on the prism serves as an indicator. A milled-edge wheel is placed at the periphery to facilitate the rotation of the prisms. When the indicator points to zero on the scale the prisms exactly neutralize each other, and their effect is that of a plane lens. Rotation increases their

Fig. 267.—Savage's Cyclophorometer.

strength, so that when their bases are exactly
prism of 30 degrees is obtained.

The **line-and-dot test** of von Graefe is not u
ployed to determine insufficiency of the lateral
ordinary reading distance. The patient is direc
card containing a black dot through which pass
3 inches long, at a distance of 13 inches. A pri
is placed base down before the right eye. Diplo
and the relation of the images indicates the m
In orthophoria the dots are directly over each otl

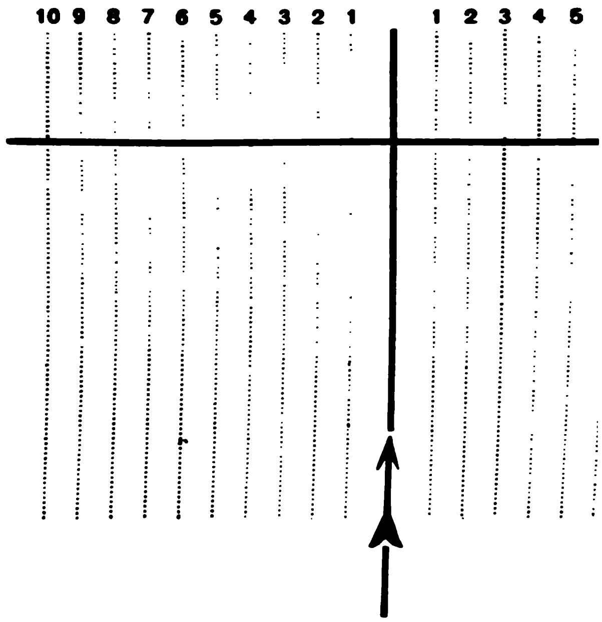


FIG. 268.—MODIFICATION OF LINE AND DOT

The card is to be held at 50 centimetres from the patient's eyes. A 10-d
base downwards, is placed before one eye. The double images are dis
the upper one on the transverse line. The number of lines that the
placed laterally indicates the number of degrees of the prism required
phoria, or esophoria. Hyperphoria may be measured by turning tl
and placing the prism with its base towards the nose.

vertical lines form one long continuous line. Displa
upper image to the right indicates esophoria, and is
the prism necessary to restore the normal relation c
The reverse displacement indicates exophoria, and i
the same manner. Jackson's dot test is also of val

and a 5-degree prism, base up, behind one of them. The patie: sees two horizontal lines of light, which should be parallel an the ends even. The latter can be regulated by varying the pupil-lary distance. If the lines are not parallel they may be made s by rotating either Maddox rod, the kind (plus and minus) an degree of the error being shown on the scale. Cycloduction the intrinsic power of each oblique muscle or of both superior or of both inferior obliques may also be measured.

Heterophoria.—The symptoms produced by heterophoria ar those of asthenopia of the muscular variety. Pain in the eye photophobia, headache, vertigo, car sickness, etc., are pronounc in disturbances of muscle equilibrium, and while suggestive c heterophoria are by no means diagnostic. In all cases, the cond tion of the muscles should be noted as a routine measure.

The treatment of heterophoria is influenced by a number factors, all of which should receive consideration. As the cond tion owes its production in large part to some form of unco rected ametropia, this error of refraction should be corrected i mediately under the influence of a mydriatic, preferably atrop The influence the accommodation exercises over the muscle b ance may be easily ascertained by comparing the results of muscle tests obtained without a mydriatic with those obtai under mydriasis.

If the response to this part of the treatment is not prom and the condition persists, the general muscle tone through the body should be improved by outdoor exercise, plenty of fr air, the restriction of close work, tonics, etc., all of which c tribute to the relief of the condition. Two classes of inter remedies suggest themselves when the symptoms are mark namely, nerve sedatives of which the bromids are types, a nerve tonics, represented by strychnin, arsenic, and nux vomi The bromids are of temporary value in relieving distres symptoms and affording a rest to the muscles when exhaust is imminent. When the condition is one of mild fatigue administration of small doses of strychnin or nux vomica is great value in restoring tone to the muscles. Prism exercises also of great value in heterophoria. In pronounced cases ten omy or some other muscle operation may be performed.

In insufficiency of the adductor group of muscles, so comm

in myopic defects, the oculist has in addition to the correction of the ametropia a choice of four treatments: the prescribing of prisms, ocular gymnastics, the advancement of the internal recti or tenotomy of the external recti muscles.

In prescribing prisms, the degree required is obtained by the tests previously explained. The full strength is seldom prescribed, it is usually reduced one third, and is divided between the two eyes, with bases in. Decentering the lenses may also be employed.

Exercises of the ocular muscles should be given a fair trial in all cases. An easy exercise is to have the patient fix the gaze upon the finger or other object held a short distance from the eye. The finger is brought close to the nose until diplopia is produced. In this manner convergence is stimulated and maintained until diplopia is produced. The frequent repetition of this procedure is of great value.

Another valuable exercise consists in overcoming prisms of increasing strength placed before the eyes, bases out. The correcting lenses should be worn, and the patient stationed about one foot from a steady light placed at the level of the eye, toward which he is directed to look. A pair of weak prisms (about 5 or 10 degrees) is placed, base out, in a trial frame before the eyes. At this distance binocular vision is perfect. The patient is directed to walk backward, or the light is carried away until diplopia is produced. If this occur inside of 6 meters the exercise is repeated with weaker prisms. When a distance of 6 meters is reached and perfect binocular vision is maintained, the prisms are raised and an attempt is made to fuse the double image seen. If this is successful, the exercise is repeated with stronger prisms. The exercise should be performed three or four times a day, and the strength of the prisms should be gradually increased.

Tenotomy and other muscle operations are of great value in this class of cases, but their description will be fully given under Muscle Operations. The prismatic exercises are very useful adjuncts to all operations upon the ocular muscles.

In insufficiency of the external muscles the ametropia should be corrected at first, and the eyes afforded a complete rest for ten days or two weeks by the instillation of atropin (gr. j to ℥j). When it is impossible to have this performed 1 drop of homatro-

pin (gr. x to ℥j) or scopolamin in solution (gr. ½ to ℥j) should be instilled into the eye just before going to bed for several nights. This relaxes accommodation and convergence during the night and does not incapacitate the patient for his daily work. Prisms may also be prescribed, bases out, but exercises are of no value whatever. In high degrees operations upon the muscles have been advised.

In disturbances of the vertical muscles the full prismatic correction that relieves the symptoms should be prescribed.

In disturbances of the oblique muscles, rhythmic exercises in which high convex or concave cylinders are rotated before the eye "fixed" on a flame are of great benefit.

Strabismus, Heterotropia, or Manifold Squint.—A condition of incoördination of the ocular muscles in which the degree of insufficiency is too great to be overcome by increased muscular effort. The visual axis of one eye only is directed toward the object. This is known as the fixing eye in contradistinction to the other or deviating eye. There is always a marked diminu-

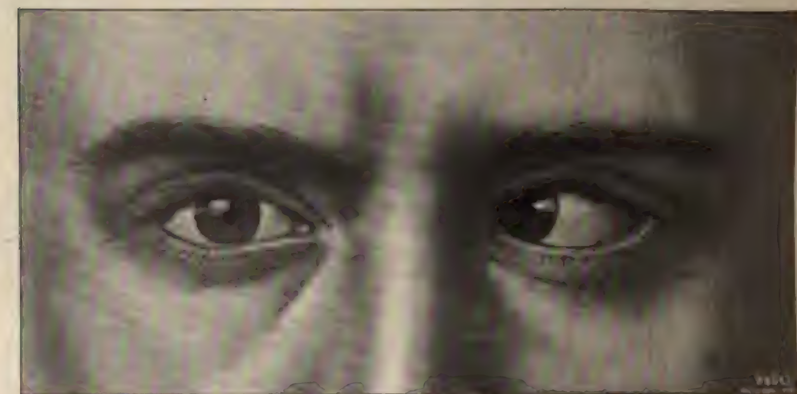


Fig. 270.—Convergent Strabismus.

tion in the visual acuity in the squinting eye. Correcting lenses usually improve the vision, but occasionally they will be found to have no effect whatever.

Varieties of Strabismus.—*Convergent strabismus* is a form of this condition in which one eye deviates inward while the other eye fixes upon the object. It is also known as internal squint and esotropia. It is the most common form of squint, and is usu-

ally associated with hyperopia, most marked in the squinting eye. The resultant diplopia is homonymous in character.

Divergent squint is the opposite condition; one eye fixes on the object and the other deviates externally. Exotropia and external strabismus are synonymous terms for this condition. Myopia is usually present in this form of strabismus.

Vertical squint or hypertropia is the form in which the visual axis of one eye deviates upward.

Monolateral or one-sided squint is the term applied when the squint is a constant condition of one eye only.

Periodic strabismus is a variety in which the deviation is only occasionally present in one eye. It is due to excessive close work, and precedes some other form of strabismus.

Alternating strabismus is present when the deviation is present alternately in each eye. The vision is usually equal in both eyes, but the changing of the squint from one eye to the other is probably due to employing one eye for distance and the other for close work.

Concomitant squint is characterized by free movement of the eyes in all directions, but an inability to "fix" is manifested by one eye, giving rise to inward or outward deviation.

Spastic squint is a form resulting from a spasmodic contraction of one or more muscles. It is a rare condition. Spasm of accommodation is occasionally attended by internal strabismus, transitory in character, due to a more or less spastic condition of the internal recti muscles.

Paralytic squint is distinguished from the other varieties by a restriction of movement in one or more directions owing to a palsied condition of one or more muscles.

Etiology.—The causes of squint are various, but for convenience in description they may be grouped in three classes: errors of refraction, anatomical peculiarities, and blindness.

In the *first class* belong those cases which, by reason of hyperopia or myopia, internal or external squint has taken place. The relation between these forms of ametropia and the extra-ocular muscle balance has already been described at length in a preceding chapter. In cases due to high errors of refraction diplopia is produced, but the false image becomes blurred and suppressed in a short time. If appropriate treatment is not promptly insti-

tuted, the function of the retina is to a great extent lost and *amblyopia exanopsia* or blindness from disuse follows. It is to this class of cases, therefore, that treatment offers the greatest hope for cure.

In the *second class* may be included the peculiarities of the face and orbit that allow or restrict freedom of movement of the eyeballs. In this class may also be placed anomalies in shape, size, and attachment of the ocular muscles.

The *third class* consists of blindness, congenital or acquired. A blind eye is incapable of "fixing" upon an object on account of the afferent impulses not being carried to the centers in the brain. In congenital amblyopia the eye-ground is not in condition to transmit impulses, and in the acquired form it is unable to receive them, owing to various opacities in the dioptric system, such as maculæ, leucoma, cataract, vitreous opacities, etc.

To determine the presence and degree of strabismus, the tests described under heterophoria may be employed, but on account of the reduced sensibility of the retina of the deviating eye they may be very unsatisfactory. Owing to the fact that the sensitiveness of the nerve tunic is retained in large part for red, a plane red glass placed before the squinting eye may serve to bring out the false image.

The cover test as employed in heterophoria is also of great service in this connection. The degree and character of the squint may be easily determined by noting the primary and secondary deviation.

The strabismometer has been extensively employed to estimate the deviation of the eyes in strabismus, but is seldom used at present on account of its inaccuracy. It consists of a piece of ivory hollowed on one side to fit the curve of the eyeball, on the edge of which is marked a graduated millimeter scale. The instrument is held to the eye so that the zero mark on the scale corresponds to the center of the pupil while the eye "fixes" on some distant object. The eye is then covered and the other eye fixes on some close object. As the first eye is uncovered its deviation is noted, each degree on the scale representing 5 degrees deviation.

The most accurate of all tests for estimating the degree of strabismus is the perimeter test. The patient is seated in front

of this instrument so that he squinting eye is directed toward the center of the instrument. Both eyes should then be directed toward some distant object in the median line opposite the patient. The arc of the perimeter should be placed horizontally and a candle flame, placed first at the fixation point, should be brought out gradually on the inner surface of the arc until the eye of the observer, directly back of the candle flame, can see its image in the pupillary center of the squinting eye. The number registered on the arc at this point indicates the degree of deviation.

Stevens' Tropometer.—An instrument for the determination of the various ocular rotations. It consists of a telescope mounted

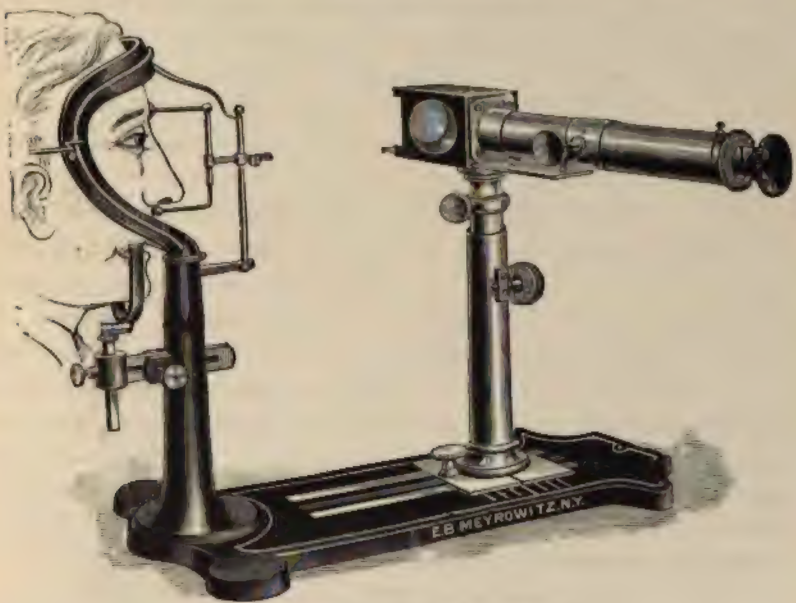


FIG. 271.—STEVENS' TROPOMETER.

upon a suitable stand with a head rest for maintaining a primary position of the patient's head. An adjustable stirrup is provided for this purpose, and the bulbous extremities of two guiding rods indicate when this position has been attained. The upper rod should be in contact with the face at the glabella above the root of the nose, while the lower should be placed at the center of the upper lip. The patient is then instructed to gaze di-

the first time to remedy the condition for cosmetic purposes, both the patient and his friends being wofully ignorant of the reduction of visual acuity in the "crossed" eye. This is particularly true of children in whom the condition is attributed to all sorts of impossible diseases.

Bearing the causes of strabismus in mind, it is obvious that in most cases the eye should be placed at prolonged rest under the influence of atropin. The employment of homatropin and other rapid-acting cycloplegics in this connection defeats their purpose on account of the short duration of their effects. The refraction should be examined into frequently, and before the mydriatic has lost its effect the correcting lenses should be prescribed and worn constantly. The retinoscope finds its greatest field of usefulness in this condition on account of the obtunded sensibility of the retina in the squinting eye, it being often impossible to distinguish the largest letters on the test cards.

Not infrequently the squint disappears by the instillation of atropin alone, and less commonly it reappears when accommodation is once more established. Such cases require prolonged cycloplegia with the constant wearing of dark glasses during this period.

A very efficient exercise for bringing the squinting eye to fixation is the blinder exercise. The better eye should be covered for a period of fifteen to thirty minutes three or four times daily. The correcting lenses should be worn and the blinder placed before the good eye. This is least annoying if performed while eating the meals. The prognosis with this treatment in young children is extremely gratifying.

Worth's Amblyoscope.—For the exercising of the fusion faculty in young children who may be subjects of strabismus, Worth has devised an instrument to which he applies the term "amblyoscope." It consists of two halves joined by a hinge, each of which is made up of a very short tube joined to a longer one at an angle of 120 degrees. A mirror is placed at the free end of the long tube, and a lens the focal length of which is equal to the distance of the reflected image of the object glass is placed at the free end of the shorter tube. The hinge allows changes in the relative position of the two halves, so that the instrument may range in its adaptability from 60 degrees of convergence to 30

degrees of divergence. The object glasses are covered by tra
lucent paper on which may be figures of 3 classes: 1. Bird and
cage, mouse and trap, etc. 2. Figures incompletely made on ea
slide, so that fusion of the images is necessary to perceive t
entire object. 3. Stereoscopic pictures.

In the application of the instrument the child should wear
proper correction and the object glass of the first class should

FIG. 273.—WORTH AMBLYOSCOPE.

employed. The patient should be directed to put the bird in
cage or the mouse in the trap. Each tube should be illumina
by a portable lamp placed in its axes and about 4 feet from
The object before the better eye is seen immediately, but that
fore the other eye is not perceived at all. The lamp in front
the object best seen is moved away and the other lamp is brou
closer to its corresponding tube until the other object is se
The intensities of the illumination are then adjusted so that b
objects are seen. The angle of the instrument is changed so t
fusion occurs. As the fusion becomes more developed the an
of the tubes may be varied considerably.

In adults, correction of ametropia, prisms, and prism ex
cises may be tried, but the success attending such procedu
alone is not very encouraging. Tenotomy, advancement,
other operation upon the muscles at fault is usually necessa

Operative interference, however, should always be preceded by a careful examination of the defective eye in every particular, and be followed by prism exercises and examination of the refraction.

Paralysis of the Ocular Muscles.—An impairment of the function of one or more ocular muscles is known as *paresis;* absolute loss of function, temporary or permanent, is termed *paralysis.* The latter may be congenital or acquired.

Congenital paralysis attacks the levator palpebræ superioris, most often giving rise to ptosis or drooping of the upper lid. Impairment of the function of the external rectus may also be congenital, but is less frequent.

Acquired paralysis results from general diseases which affect the nerves supplying the muscles in some part of their course from the cortical centers of their distribution in the muscles themselves. The tertiary manifestations of syphilis and tubercular meningitis are perhaps the most common causes. It is frequently associated with locomotor ataxia and general paralysis of the insane. Blood clots, tumors, abscesses, aneurysms, head injuries, fracture of the skull, etc., may also induce the condition by pressure upon the nerves or nerve centers. The infectious fevers, particularly diphtheria and influenza, are important etiological factors. Less frequently the affection arises from the toxins of rheumatism, tuberculosis, diabetes, typhoid fever, nephritis, etc. Exophthalmic goitre is also said to be an occasional cause. Among the more remote factors in its production may be mentioned tobacco, alcohol, lead, ptomains in decomposing food, carbon-dioxid gas, hysteria, and exposure to cold.

Acquired paralysis may be complete or partial. Total ophthalmoplegia consists of loss of function of all the ocular muscles, and results from some very serious condition of the brain. Partial paralysis is confined to one or more sets of the muscles of the eye. It may be divided into internal, external, and total ophthalmoplegia. It may be acute or chronic.

Internal ophthalmoplegia is an infrequent condition in which the ciliary muscles and the circular and radiating fibers of the iris are involved. Palsy of the ciliary muscles alone is not so rare, and is most common after diphtheria, the instillation of mydriatic drugs, and sometimes traumatism.

External ophthalmoplegia consists of suspension of functio the four recti and two oblique muscles of the eye. When paralysis involves all these muscles at the same time, locom ataxia is usually the cause. Partial external ophthalmoplegi the most common form of ocular paralysis and is manifested strabismus.

This form usually arises from involvement of the nerves plying the muscles, but may be due to some disease of the mu themselves. The third cranial or oculomotor nerve, if its f tion undergoes any alteration, induces palsy of the levator p bræ, the superior, inferior, and internal recti, the inferior obli the sphincter pupillæ, and the ciliary muscle. Impairment of sixth nerve results in loss of function in the *external rectus* *cle.* Any pathological condition of the fourth cranial nerv duces palsy of the *superior oblique muscle.* When both int and external ocular muscles are involved, it is called *total* *thalmoplegia* (ophthalmoplegia totalis).

Symptoms.—One of the most prominent symptoms of p ysis is the limitation of motion corresponding to the pa muscle. It is most marked when the patient attempts to fo the movement of some close object by the eyes alone. This tation will also bring out another symptom, that of squint. is present only when the eyes are moved in the direction of paralyzed muscle. Movement in the opposite direction b normal, the deviation of the squinting eye is in a direction o site to that of the affected muscle, and is known as prir deviation. If the squinting eye "fixes," the sound eye deviate in a corresponding direction, but to a greater deg This is known as secondary deviation. This difference i importance in distinguishing paralytic squint from concom strabismus, in which the primary and secondary deviation equal.

There is always more or less false projection of images, indicated by the failure to locate objects properly, and from naturally arise uncertainty in gait and incoördination of o movements of the extremities.

The patient complains also of double vision or diplopia w looking at objects within the sphere of action of the paraly muscle. This is increased by movement of the eyes in the di

tion of the affected muscle and decreased by movement in the opposite direction. In order to assist in diminishing the diplopia, the patient unconsciously turns the head obliquely toward the side corresponding to the palsied muscle.

Other subjective symptoms deserving mention are nausea, vomiting, mental confusion, a sense of insecurity, etc., all of which are greatly relieved by occluding the affected eye by a blinder.

The characteristic symptoms disappear to a great extent, as the duration of the palsy increases, even when the function is not reëstablished. The patient becomes accustomed to the diplopia and the false image is more or less blurred and suppressed. As a late result contraction of the opposite muscle is greatly increased and the squint becomes more pronounced than formerly.

The diagnosis is made by the limitation of motion and the position and relation of the images to each other. The placing of a red glass before the squinting eye will cause the false image to be colored and the examination will be greatly facilitated.

Paralysis of the external rectus is characterized by limitation outward, convergent strabismus, and turning of the head toward the paralyzed side. If the patient looks toward the paralyzed side homonymous diplopia is produced. The images are on the same level, and the false image is in the central portion of the field. Turning of the eyes toward the palsied muscle increases the lateral separation. This form of ocular paralysis is the most frequent, forming about one third of all such cases.

Paralysis of the internal rectus is attended by limitation of movement inward. Diplopia is produced when the patient looks toward the affected side, and is heteronymous or crossed in character. Adduction of the sound eye increases the distance between the images, which are always on the same level.

Paralysis of the superior rectus is manifested by a change in the relative positions of the images in addition to their crossing. The false image is above and inclined away from the true image. This inclination is increased by looking toward the sound eye.

Paralysis of the inferior rectus is also attended by an alteration of the images in their relation to each other. The false

image is below and inclined toward the true image. The dip pia present is of the crossed variety.

Paralysis of the superior oblique is the second most frequ isolated paralysis, constituting about one sixth of all the oc paralyses. The diplopia is homonymous in character and images are one above the other. The false image is bel and inclined toward the true image. Downward rotation lessened.

Paralysis of the inferior oblique gives rise to homonym diplopia, in which the false image is above and inclined somew outward from the true image.

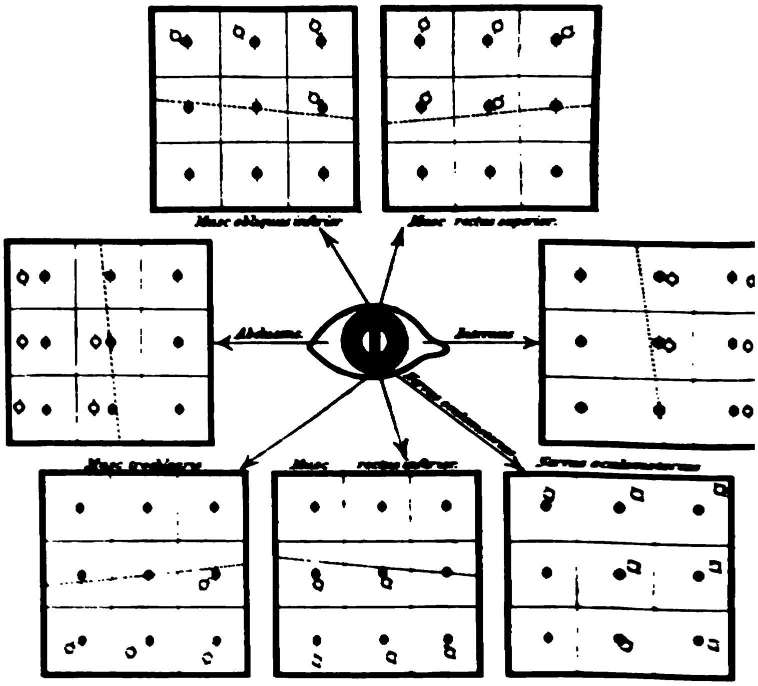


Fig. 274.—Showing Images in Ocular Palsies (Right Eye). Red Im is that of the Unparalyzed Eye.

Total ophthalmoplegia is manifested by crossed diplopia. situation of the images is peculiar, the true image being vert while the false is slightly above and its upper end is incl toward the true image. Mydriasis and ptosis accompany affection.

Prognosis.—In nearly all cases the duration of the condition extends over a long period. An exception to this occurs in the case of acute total ophthalmoplegia, in which a fatal termination takes place in a short time from the structural changes in the central nervous system. Chronic total ophthalmoplegia is unfavorable as to cure of the ocular paralysis, but the duration of life depends upon the progression of the central disease. Isolated paralysis of short onset following the infectious fevers, such as diphtheria, recover most rapidly. Occasionally an hysterical history can be elicited, and in such cases response to treatment is prompt. Paralyses the result of injury are always of doubtful prognosis. In other cases, if the presence of syphilis can be proved and the affection promptly treated, the muscle regains its function after a period of several months. Organic disease of the brain or spinal cord always influences the prognosis unfavorably. In long-standing, untreated cases the paralyzed muscles tend to atrophy from disuse and the opposing muscles undergo contraction from lack of resistance. Relapses are frequent.

Treatment.—This may be constitutional or local. In those cases in which constitutional affections, such as syphilis, gout, rheumatism, etc., are found to be the causal factors the appropriate treatment should be instituted, attention being paid to the most minute detail. Even in the absence of a clear history of syphilis or rheumatism the administration of mercury and the iodids, alone or combined, is productive of beneficial results. If the paralysis is secondary to some infectious fever, such as diphtheria, strychnin in ascending doses will be of great value. The functional paralyses such as occur in hysteria are improved by the ordinary methods employed in the treatment of functional nerve disorders elsewhere in the body.

The local treatment includes electricity, ocular gymnastics, prisms, occlusion of the squinting eye, and muscle operations.

In using electricity the constant current is most often employed. The positive pole should be applied to the back of the neck and the negative pole directly over the affected muscle. In the beginning the strength of the current should not be over 1.5 milliampères, otherwise annoying flashes of light will be experienced by the patient. Later the current may be increased to 3 milliampères.

Ocular gymnastics, in this connection, consist largely in lowing the patient to wear prisms that almost correct the dip pia. An attempt is then made by the paralyzed muscle to ov come the remaining portion. An increase in the ability to do is a favorable indication. Another exercise consists in mov the head until the images are fused, and then attempting bring about the same result without moving the head. To rive any permanent benefit from these exercises it is neces to repeat them carefully eight or ten times daily.

Prisms may be prescribed and worn constantly to overc the diplopia, but on account of the weight and attendant c matic aberration in the high-degree prisms necessary for purpose they are frequently discarded by the patient.

A simple method of treatment consists in occluding the p lyzed eye from partaking in vision by means of a cylinder, pa or bandage. This prevents the annoyance occasioned by diplopia, but in no manner hastens recovery.

Among the muscle operations advised for ocular paral may be mentioned muscle-stretching, tenotomy, and advancem alone or combined. They are best adapted to obstinate c and frequently their only result is cosmetic in character.

Nystagmus.—An affection involving the motility of the balls manifested by rapid involuntary oscillations of those org It is bilateral in character. The movements are jerky and s modic, and do not replace the normal movements of the but accompany them. The movements may be lateral, vert oblique, or rotary in direction, and are often attended by c sponding movements of the head. Imperfect vision and turbances of the extra-ocular muscle balance are frequently a ciated with the condition. The lateral form is most com Unilateral nystagmus is more rare, but has been observed several authors.

Among the causes of nystagmus may be mentioned spa in the [illegible] system, intra-ocular diseases, albinism, catar anemia, congenital cataract, microphthalmus, retinitis pig tosa, errors of refraction, and disseminated sclerosis.

Miners' Nystagmus.—An interesting variety is that found [illegible] is probably developed by constant s [illegible] the semi-recumbent posture they are [illegible]

to assume while at work. According to Snell, it is due to prolonged upward rotation rather than insufficiency of illumination.

Miners' nystagmus is most amenable to treatment, the affection disappearing as the patient changes his occupation. In other cases nothing is of value except possibly the correction of errors of refraction. Sometimes the affection is choreiform in character, disappearing during sleep and as age advances.

NORMAL DECLINATIONS OF THE RETINAL MERIDIANS

That the retinal meridians are subject to normal deviations was first pointed out by Dr. George T. Stevens, of New York City. He defines normal declinations of the retinal meridians as a deviation of the vertical, horizontal, or any given meridian of the eye from the corresponding meridian of external space, when the line of regard of the eye is directed parallel to the median plane and in the horizontal plane, the head being exactly erect or, more technically, in the primary position. The following diagram of Stevens serves to explain this definition very well.

The equator of the eyeball is represented by the circle *e a c*, *f b d*, and the line *a b* represents the normal position of the vertical meridian of the eye. When this line corresponds with the vertical meridian of surrounding space there is an entire absence of declination, but if it deviates to either side by a rotation upon its antero-posterior diameter, the meridians no longer correspond with those of external space, and declination is present. When the top of the meridian line, *c d*, inclines toward the temple it is known as *positive* or (+) declination, but if the top of the line, as *e f*, leans toward the nose it constitutes negative or (−) declination.

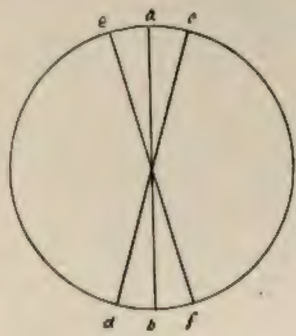


FIG. 275.

Declinations of the meridians may be physiologic or pathologic. Physiologic declination is the common form and may be regarded as an anomalous condition. It probably results from variations in the size and shape of the orbit and the insertions of

the extra-ocular muscles. It is also known as normal decli-tion.

Pathologic declinations are those that follow insuffici[illegible] paresis, or paralysis of one or more ocular muscles, as the re[illegible] of disease or injury.

Many of the *symptoms* associated with normal declinat[illegible] are similar to those attributed to heterophoria. One of the m[illegible] festations is dryness of the eyelids with the sensation of a for[illegible] body within them. There is often chronic hyperemia of a r[illegible] persistent type, which is undoubtedly due to pressure of the [illegible] against the eyeball in an effort to steady the globe and resist [illegible] tendency to roll incident to the declinations of the merid[illegible] The patient also complains of long-continued pain over on[illegible] both eyebrows. Inspection under such circumstances often [illegible] veals undue arching of one or both brows, and the pain is at[illegible] uted to muscular effort on the part of the brow muscles in [illegible] less attempts to overcome declinations. Changes in the con[illegible] of the brows are in a great number of instances indicative of [illegible] directly due to normal declinations of the retinal meri[illegible] Visual disturbances may also be traced to this same cause. Dr. Stevens states that the amblyopia, that is not infrequ[illegible] found in apparently well eyes in which there is no squint, is [illegible] caused by this declination of the meridians. Asthenopic sy[illegible] [illegible] and are particularly well ma[illegible] [illegible] and heterophoria. The [illegible] [illegible]

declination or with very little, and usually of the same sign as that of the first eye. In esophoria declination is almost uniformly found in both eyes, and the leanings of the meridians are homonymous, as, for instance, if the declination is positive for the right it is negative for the left.

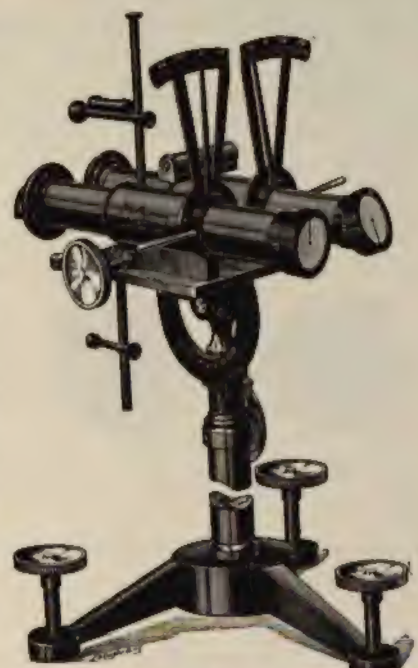


FIG. 276.—CLINOSCOPE.

The relation between heterotropia or strabismus and declination is similar to that between heterophoria and declination, but the declination is of greater degree.

The presence and degree of declination can only be satisfactorily determined by means of the clinoscope devised by Dr. Stevens. It consists essentially of two hollow tubes; at one end of each is a pinhole opening through which the eye looks, and at the other end is a translucent disk on which a straight vertical line is drawn. One disk has the line drawn from the center straight up to the periphery, while the other disk has the line drawn down from the center to the periphery (Fig. 277). As it is necessary to maintain the tubes in the same horizontal plane, the attached spirit level is essential. The tubes rotate on their long axes and a pointer attached to each tube indicates on a scale the extent to which the tube is rotated. The extremities containing the sight holes may be adjusted so as to suit the interpupillary distance in different indi-

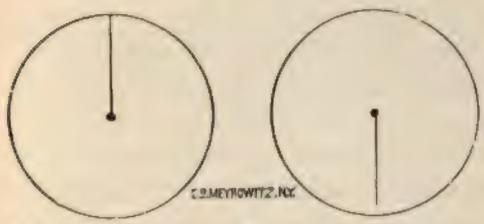


FIG. 277.—OBJECTIVE LINES OF CLINOSCOPE.

MUSCLE OPERATIONS

The principal operations performed upon the extra-ocular muscles for errors of coördination are muscle-stretching, tenotomy, and advancement.

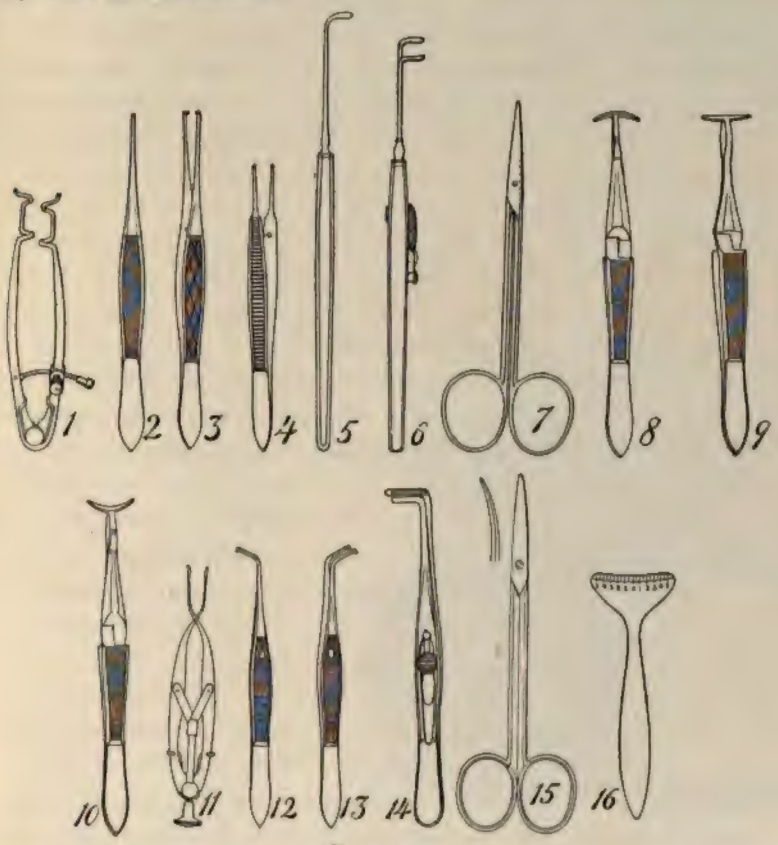


FIG. 279.

(1) Speculum; (2 and 3) Fixation Forceps; (4) Fixation Forceps (Stevens'); (5) Strabismus Hook; (6) De Wecker's Double Strabismus Hook; (7) Strabismus Scissors; (8, 9 and 10) Traction Forceps; (11) Todd's Tendon Tucker; (12 and 13) Prince's Muscle Forceps; (14) Pfluck's Forceps; (15) Curved Strabismus Scissors; (16) Laurence's Strabismometer.

Muscle-stretching is an operation devised for the relief of the squint in obstinate cases of ocular paralysis. The conjunctiva overlying the paralyzed muscle is grasped by means of fixation forceps, and the eyeball is forcibly rotated several times toward the affected side. This relaxes the contraction of the opposing muscle and prevents the formation of adhesions. The relief

afforded by this procedure requires its repetition to be of val Marked contraction of the opposing muscles is always an indi tion for its performance.

Tenotomy consists in severing the stronger muscle at its tachment to the eyeball. It is indicated in marked cases squint, and may be performed alone or in combination w advancement. There are two methods: the open (von Graefe and the subconjunctival (Critchett's). In either operation surgeon should be provided with the following instruments

Eye speculum.
Fixation forceps.
Stevens' scissors.
Pointed strabismus scissors (English model).
Strabismus hook, English model or Stevens'.
Needle holder, needles, silk, tray.

In the open method the eye is anesthetized by the instillat of a 5-per-cent cocain solution, one drop every five minutes twenty minutes preceding the operation (Fig. 280). The c junctival *cul-de-* should be irrigated w a warm boric-acid so tion to render the eye aseptic as possible. this as in other ophtl mic operations the s geon's hands should well cleansed and r dered aseptic by imm sion in alcohol or ot germicidal solution. T placing of the inst ments in alcohol [alco

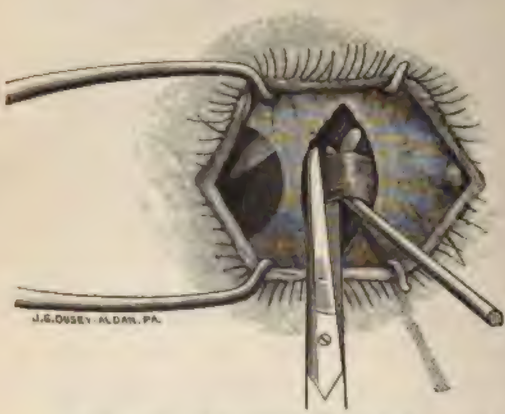


FIG. 280.—TENOTOMY (OPEN METHOD).

ʒij (8.0), aqua destil. ℥vj (180.00)] for a period of fifteen thirty minutes renders them sterile without destroying the ed or inducing rusting. Purulent inflammation of the conjunct or lacrymal apparatus is a contraindication to any operation this kind. Children under ten years of age should never be su jected to any muscle operation.

After the preliminary preparations have been completed

patient should lie flat upon the back upon a suitable table and the eye speculum is introduced to hold the eyelids apart. The patient is directed to look straight out so that the relations of the various structures may not be disturbed. The conjunctiva over the lower portion of the muscle at its insertion is incised about 2 to 4 mm. from the corneal margin, and is dissected backward and downward beyond the lower border of the muscle, thereby exposing it. A strabismus hook is introduced beneath the muscle, which is then raised and divided near the sclera.

In the subconjunctival method the eye is prepared in the same manner and the eye speculum is then introduced (Fig. 281). The conjunctiva, subconjunctival tissue, and Tenon's capsule overlying the lower portion of the muscle's insertion, are grasped by fixation forceps and raised, after which they are divided horizontally by scissors. The fold of conjunctiva is raised and a strabismus hook is introduced beneath the muscle. The hook is then raised so that the tendon of the muscle is brought to the wound in the conjunctiva. The tendon is divided close to the sclera and the hook is inserted once more to make certain that the division of the tendon has been complete. The ordinary hemorrhages encountered may be controlled by sponging, cocain, or adrenalin (1–1,000).

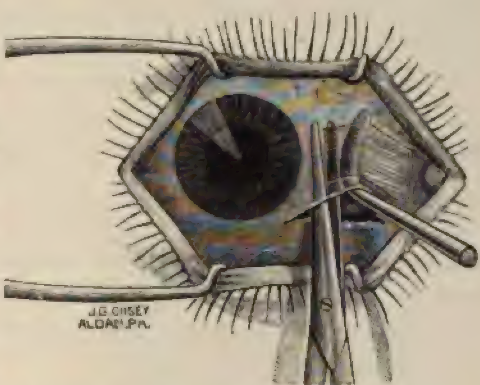


FIG. 281. — TENOTOMY (SUBCONJUNCTIVAL METHOD).

Inflammatory reaction seldom occurs and may be lessened by the application of iced compresses for ten or fifteen minutes every three hours. The position of the eyes should be noted immediately after the operation as well as subsequently, as the effect of the operation may be in excess of the result desired. When the immediate result is perfect, divergence usually follows at a later period, so that convergence should not be entirely absent directly after the operation to obtain a permanent satisfac-

tory result. The placing of the eyes at rest for a few days p to the operation by the instillation of atropin and the use o occlusive bandage aids the efficiency of this procedure materi

In graduated tenotomies a small vertical opening is mac the conjunctiva, the muscle is seized near its insertion, a

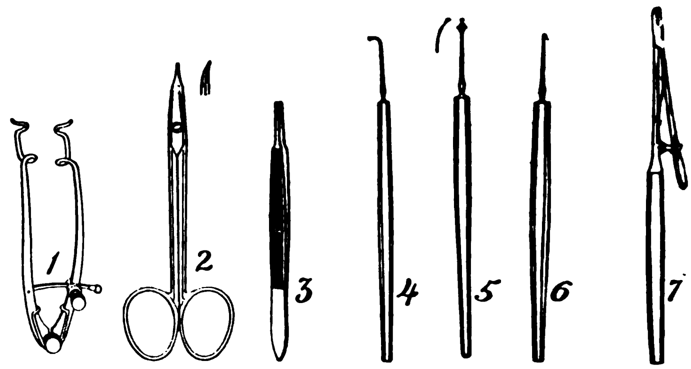


FIG. 282.—STEVENS' TENOTOMY INSTRUMENTS.
(1) Speculum; (2) Tenotomy Scissors; (3) Fixation Forceps; (4) Tenotomy Hook; (5) Di (6) Traction Hook; (7) Needle-holder.

small central opening is made dividing the tendon on the sc This may be enlarged according to the judgment of the surg but the muscle is never completely divided. These opera are employed in lower degrees of squint than the preceding n ods (Stevens).

Advancement.—The operation of advancement is inte to increase the power of the muscle to move the eyebal advancing its attachment. The weaker muscle is always sele It may be performed alone, but is productive of better re when combined with tenotomy. The preparations for this c ation are much the same as in tenotomy.

The instruments necessary are the same as those use tenotomy. After the eye speculum has been introduced a ver incision 10 mm. in length is made in the conjunctiva mid between the cornea and the insertion of the muscle. The un lying attachments of the conjunctiva are freed over the ten An incision is made in Tenon's capsule at the lower borde the muscle, and a hook is introduced through this opening neath the muscle, which is then freed of all its attachment surrounding structures. This is followed by the passing of tl

strong sutures through the muscle from behind forward; one through the center of the muscle, one near the upper margin, and one near the lower margin. The introduction of these sutures should be such as to include the capsule of Tenon and conjunctiva with the muscle. The tendon should then be divided near its insertion, or a portion excised according to the judgment of the surgeon and the effect desired. The central suture is continued beneath the conjunctiva, passes through the more superficial layers of the sclera, and emerges at the margin of the cornea in its horizontal meridian. The upper and lower sutures pass obliquely beneath the conjunctiva above and below the cornea. The outer layers of the sclera are transfixed by the sutures, which finally emerge at the upper and lower corneal margins respectively in the vertical meridian. The eyeball is then rotated inward, so that the degree of advancement necessary may be ascertained, and the sutures are tied while the eye is in this position. A few interrupted sutures are used to close the conjunctival wound, after which the eye is bandaged and the patient placed at rest in bed for a day or two. Inflammatory reaction may be controlled by cold compresses and irrigation with boric-acid solution. The sutures should not be removed for one week at least, unless it is desired to diminish the effect of the operation. Overcorrection is necessary at all times to obtain a perfect result in the end.

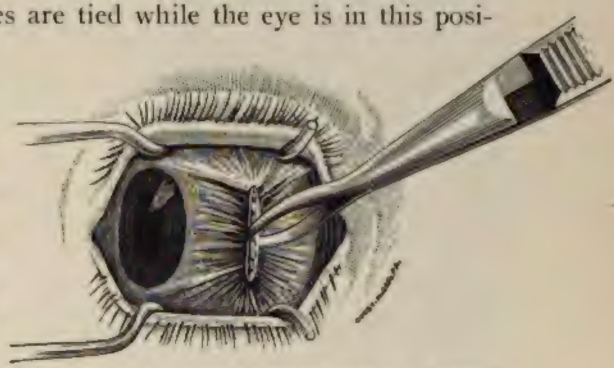


FIG. 283.—AUTHOR'S OPERATION FOR DIVERGENT SQUINT. (First Stage.)

Capsular advancement is an operation employed in the lower degrees of squint, and consists in shortening or advancing the capsule of Tenon over the affected muscle.

An ingenious instrument for shortening the muscle is the "tucker" devised by Todd. It consists of a pair of spring forceps, the lower ends of which are so formed as to cross each other, and separate when the forceps are closed and maintained so by a screw attachment. The upper and crossed prong is in-

serted beneath the muscle, while the lower prong is above t[illegible]
structure. As the spring is released the prongs of the instrum[illegible]
approach and pass each other, forming a fold or tuck in [illegible]

FIG. 284.—AUTHOR'S OPERATION FOR DIVERGENT SQUINT. (Second S[illegible]

muscle. Catgut sutures are passed through and through [illegible] muscle to fasten it on itself, and silk sutures are employe[illegible] secure the muscle loop to the conjunctiva and episcleral ti[illegible]

FIG. 285.—AUTHOR'S OPERATION FOR DIVERGENT SQUINT. (Completed.)

The muscle balance sh[illegible] be taken frequently after these operations. The full [illegible] rection of any error of re[illegible] tion should be prescribed [illegible] worn constantly, and prism [illegible] ercises should be regu[illegible] performed.

Author's Operation for [illegible] vergent Strabismus.—In di[illegible] gent strabismus the follo[illegible] operation has given the bes[illegible] sults in the author's experience; it is best adapted to case[illegible] which the deviation is 5 mm. and upward.

The operation is divided into three parts, and is performed under cocain: (1) Tenotomy of both external recti muscles and stretching of conjunctiva and Tenon's capsule; (2) making the elliptical opening either on one eye or both; (3) suturing this opening.

The details of the operation are carried out as follows:

1. Tenotomy of both external recti muscles, making an opening through the conjunctiva, over the insertion of the tendons. Tenon's capsule is then stretched until the cornea is well into the inner canthus—this is done on both eyes. The stretching of

FIG. 286.—DIVERGENT STRABISMUS BEFORE OPERATION.

Tenon's capsule is an important part of the operation, and should be performed as follows: The strabismus hook, which is a large one, flat on its side, is inserted in the opened conjunctiva and Tenon's capsule, and with considerable traction all the tissues are stretched inward until the cornea is buried in the inner canthus. The stretching of the upper tissue has, as can be readily understood, a tendency to rotate the eyeball to a certain degree and leave the conjunctiva and Tenon's capsule intact below; to equalize the stretching, the point of the hook is reversed, and the lower conjunctiva and capsule are also stretched.

2. With the traction forceps the conjunctiva is grasped
cally, midway between the cornea and caruncle and directl
the internal muscle (Fig. 283), the conjunctiva and as m
possible of Tenon's capsule being drawn upward. The f
should be raised two or three times to take up as much
redundant tissue as judgment may dictate, and by this mea
apparently is always successful in separating conjuncti
overlying tissue from the muscle, if it be still present; the
curved scissors with one long sweep the upraised conjuncti
capsule are cut close to the eyeball, making an elliptical op
exposing at times the attenuated muscle, and, if no mus
present, then the clear sclerotic.

This opening now extends in a vertical direction, beg
below the lower level of the cornea to a point above the sa

FIG. 287.—DIVERGENT STRABISMUS AFTER OPERATION.

width over the muscle is about one full centimeter at its g
diameter. The conjunctiva is then separated around this
tical wound from its subconjunctival tissues at all points
around the cornea if possible. (Fig. 284.)

3. The elliptical opening is brought together with fo
tures; the upper suture is inserted through the conjunctiv

Tenon's capsule and across under the conjunctiva and Tenon's capsule, midway between the insertion of the superior rectus muscle and the margin of the cornea; a similar suture is passed through the lower margin of the conjunctiva and brought out midway between the insertion of the inferior muscle and the margin of the cornea; this thread is then tied, and in like manner the upper thread; two more sutures are passed through the margin of the lips of the wound and united. (Fig. 285.)

Such are the details of the operation. The object of the operator should be to produce 1 to 4 mm. of convergence, which

FIG. 288.—THE PROPER WAY OF HOLDING SCISSORS.

disappears during cicatrization. When the defect is not more than 2 or 3 mm. the author has performed an external tenotomy on both and stretched Tenon's capsule, with excellent results, without taking out the elliptical section, especially in those cases where the eyes could be held by the patient at fixed convergence at 10 inches.

CHAPTER XXIV

GENERAL OPERATIVE TECHNIC

THE **operating room** used by ophthalmic surgeons diff several particulars from that in use by general surgeons. (to the small field of operation, the light should be admitted two sides, or from the top and one side of the room, and cu or shades should be arranged so as to exclude any exc light on very bright days, to lessen the corneal reflex, a make the room absolutely dark if necessary. The room s be provided with artificial illumination, preferably electric l for use in emergency work at night. At least one light sho movable, so as to permit its use with a condensing lens for examination of the eye. Means should be provided for v tion without the production of draughts. All the chairs, t and other operating-room furniture should be made of met glass, which materials are most easily cleansed. The wal floor of the operating room should be marble for the same r

Operating tables have been devised from time to time of which has its special advantage. Many surgeons prefer bed or couch for the performance of cataract operations, re ing the high table for use in the remaining operative proce Personally, I use the high table, presently to be described, f operations in the hospital. This table consists of a brass mounted upon four legs, the forward ones being provided casters (which may be locked, if necessary) to facilitate m it from place to place. Suitable braces are placed at each to render the framework firm and durable. The brass fra made of rather thin tubing of highly polished brass, givin entire table a neat appearance, a feature that is greatly ig in most tables. The height of the table is 4½ feet, the wid feet, and the length 6 feet. The top of the frame is cover one piece of thick plate glass, on the left side of which, nea head of the table, a semicircle is cut out to enable the surge

stand more directly in front of the patient's face. A corresponding curve is made in the framework in this location. A head rest of metal and glass is provided, which permits of being raised or lowered to suit the convenience of the operator. The upper rim of the head rest is tongued on its under surface for receiving the extremities of the head clamps. The clamps, *A*, *A*, are

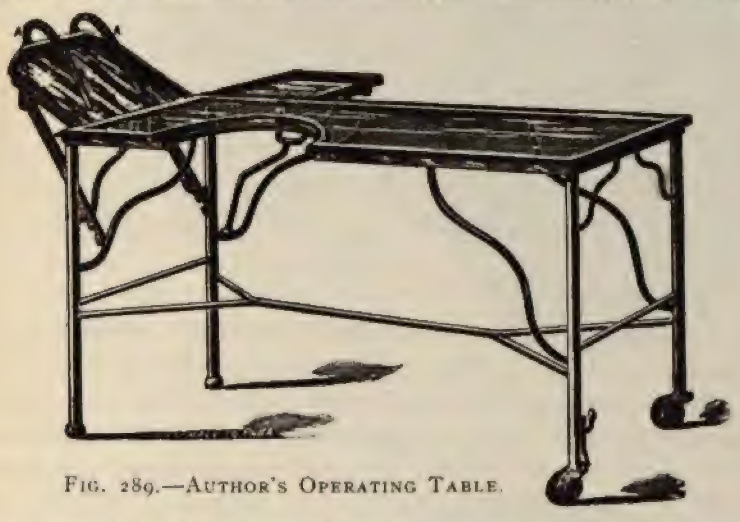


FIG. 289.—AUTHOR'S OPERATING TABLE.

two long, thin, flat pieces of metal, one end of which is heavy and thick, and grooved so as to fit snugly over the tongue of the rim of the head rest. In using the clamps, they are made to slide along the rim of the head rest until close up to the patient's head, any movement of which will cause them to bend upon the rim and become more firmly fixed. A detachable leaflet for holding an instrument tray and dressings is also provided for.

The **dressings** in use by ophthalmic surgeons should be thoroughly sterilized in the ordinary dry sterilizer or one of its modifications. Aseptic are far more preferable than antiseptic dressings, on account of the reactive inflammations of the eyelids and conjunctiva that may follow the continued contact with powerful antiseptics. It must be remembered, however, that owing to the open condition of the conjunctival *cul-de-sac* the eye is more tolerant than would be supposed at first sight. Patent lint and absorbent cotton held in place by a gauze bandage constitute the dressing for ordinary conditions.

In cases in which the bandage is undesirable, the dressing

may be held in place by a hexagon-shaped, knitted, black p
each end of which is attached a piece of black tape. Adh
plaster may occasionally be substituted for the tape. This

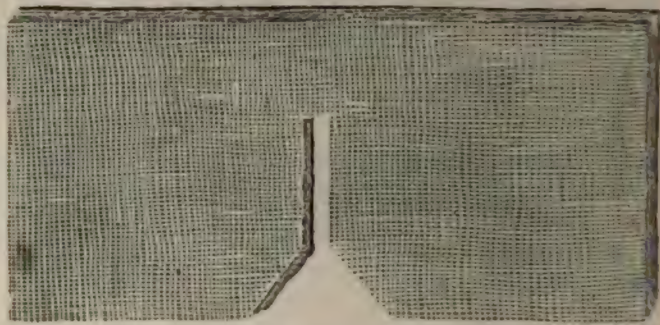


FIG. 290.—DOUBLE EYE PAD.

less conspicuous and more comfortable than the ordinary s
Liebreich bandage. When it is necessary to keep the lids cl
as after cataract operations, iridectomies, etc., sterilized pe
tum should be smeared abundantly over the closed lids
small pad, as s
in the illustra
(Fig. 291), mad
two layers of gau
closing a layer o
sorbent cotton, s
then be placed ove
eye with the curved
der corresponding t
supra-orbital arch.
large rectangular

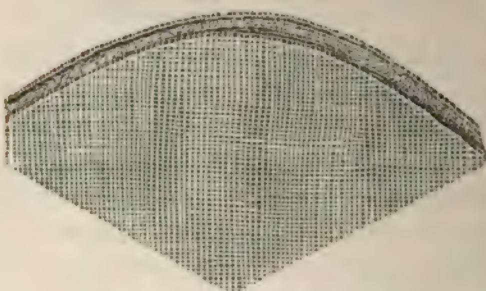


FIG. 291.—SINGLE EYE PAD.

(Fig. 290) similarly made, but with the addition of a she
black linen, is then placed over both eyes. This pad is 6 in
long and 3½ inches wide, and partially divided in the cente
order to fit over the nose. Strips of adhesive plaster are use
fasten the dressing above and below. A perforated alumi
shield (Fig. 292), molded to fit the face, should then be pl
over the eye operated upon and held in place by adhesive st

Preparatory Treatment.—Before proceeding to an opera
upon the eye, not only the condition of the ocular structures sh

be examined, but the general condition should be considered in detail. The chapter upon the Relationship between Ocular Affections and General Diseases serves to emphasize the importance of such a procedure. The urine should always be examined carefully to determine the functional activity and general condition of the kidneys. The heart and lungs should likewise be examined, as the presence of a very slight bronchitis may contraindicate any operation in which the eye is opened, on account of the increased intraocular tension that accompanies coughing. During convalescence from influenza and typhoid fever the respective bacilli of these diseases often become pyogenic in character, and may cause the failure of an operation by inducing infection through the blood. This is also true of the more serious affections, such as pyemia and septicemia, but this possibility is more likely to be overlooked in the less grave infectious fevers. The presence of any pulmonary or cardiac condition would also contraindicate general anesthesia for ophthalmic operations except in occasional emergencies. The presence of rheumatism or syphilis should be carefully sought for, but this is often impossible for various reasons. Usually it is best to avoid undue questioning in such cases, and to administer strontium salicylate, grain v (0.3), and mercury with chalk, grain j (0.06), three times daily, for several days previous to the operation. The patient should restrict his diet to vegetables for a few weeks prior to the operation, particularly if it is to be a cataract extraction. (Baron

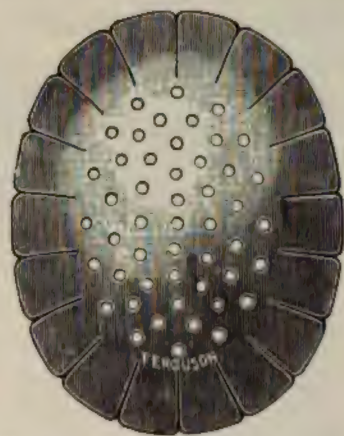


FIG. 292.—AUTHOR'S ALUMINIUM EYE SHIELD.

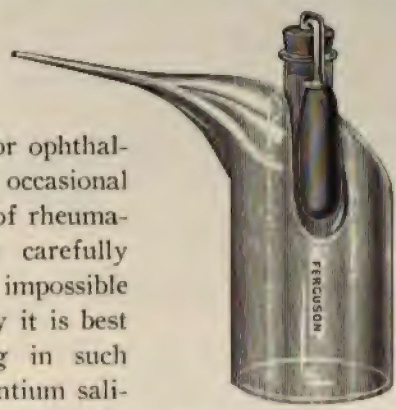


FIG. 293.—EYE-DOUCHE.

Preparation of the Field of Operation.—Th
should be thoroughly cleansed with a neutral li
hot water on the morning of the operation, care
to irritate the eye by the entrance of soapsuds i
tival *cul-de-sac*. The eye should then be thor
with a sterile boric solution, after which, pads
1–2,000 corrosive-sublimate solution should be a
until the patient is ready for operation. Upon re
the eyes are again irrigated and a drop of 1–2,00
limate solution is instilled. If the operation is
under local anesthesia, two or three drops of co
solution) should be instilled every three minutes
minutes. Using this drug for a longer period i
of the cornea and interferes with its nutrition.
(0.06), to water, drams iij (0.12), should be i
nary operations upon the cornea, lens, and iris,
comatous cases or simple cataract operations, tw
the time set for the operation. At the completio
tion, if there is reason to suspect any iritic compl
should be again instilled. The eye should be irr
boric-acid solution, and a few drops of sublimate
be instilled. The dressings already supplied sho

---

[1] In a glass-stoppered bottle dissolve

Potassium hydroxid / Sodium hydroxid	....
In distilled water	....
Add alcohol	....

plied with great care and extreme gentleness. Subsequent dressings should be made daily or at greater intervals, depending upon the character of the operation. The room in which the patient is to be confined should be as dark as is compatible with safety. If the patient is to remain in bed the room should be almost

FIG. 294.—DOUBLE EYE PAD (FIG. 290) WITH SHIELD (FIG. 292) AS ADJUSTED AFTER CATARACT OPERATION OR IRIDECTOMY.

completely dark, but if he is allowed to move about sufficient diffused light should be allowed to prevent stumbling over the furniture of the room, of which there should be as little as possible. After cataract operations the patient should be carefully watched, to prevent tearing off the dressings, which are sometimes a great annoyance, particularly in warm weather. The dressings may be removed at the end of the first week.

CHAPTER XXV

LABORATORY TECHNIC

EQUIPMENT

PERHAPS the most essential adjunct to successful laborator work is the possession of a reliable **microscope.** Without suc an instrument the student is hopelessly handicapped, and goo results are impossible. There are several good microscopes o the market, nearly all of which embody the same general prir ciples, differing only in unessential features, and the choice c which is solely dependent on individual preference. The authc has found that, although cheap grades of instruments are to t had, the greatest satisfaction will follow the purchase of a rel able apparatus—one adapted to the most elaborate work.

The observer should learn to work with either eye as clos to the lens as possible, the accommodation of the unemployed e being meanwhile suspended. It is advisable to begin the stud of a specimen with the low-power objectives, and to exclude a extraneous light so far as possible.

In carrying the instrument from one place to another should always be lifted carefully by its rigid parts, and nev by the tube or other movable delicate sections. It should t placed on a firm, strong table, about one yard distant from window, preferably with a northern exposure, and here it shoul be allowed to remain so long as practicable. When not in us it should be protected from dust, etc., by means of a glass bell ja

The objectives constitute the most important feature of th microscope. For ordinary purposes the instrument should b equipped with $\frac{2}{3}$, $\frac{1}{6}$ dry, and $\frac{1}{12}$ oil-immersion objective. Th oil-immersion differs from the dry objective in that in the forme a drop of cedar oil is placed between the front lens and the cove slip. This is done by means of a small rod supplied with th

metal oil jar. After using, the lens should always be wiped clean with a bit of fine linen or Japanese lens paper. If the oil has become gummy, the linen or paper may be moistened slightly with xylol. The advantages of the oil-immersion lens lies in the fact that the oil possesses a refractive power similar to that of the cover-glass, thus obviating the refraction of rays from the latter in the air, and increasing the intensity of the incident pencil of rays.

For focusing, the microscope is provided with two forms of adjustment—the coarse and the fine. The coarse consists of a rack and pinion, whereas the fine adjustment works by means of a micrometer screw, fitted above the prismatic column. In focusing the high-power objectives care should be observed, the lens, with the rack and pinion, being slowly brought to a point just short of touching the cover-slip, the lens being then moved away by means of the micrometer screw, the eye looking into the eye-piece until the focus is reached. It is unsafe slowly to approach the cover-slip with the lens by the rack and pinion while looking through the eye-piece, as the point of sharp focusing is too easily passed, when both the lens and the specimen are liable to be broken. Direct sunlight is to be avoided, and when artificial light is used, the blue-glass disk should be interposed between the mirror and the specimen, being placed in the socket designed for it just above the condensing apparatus. The plane

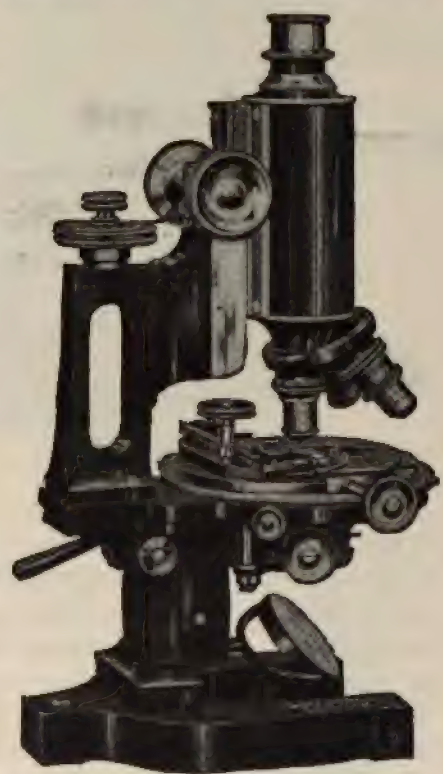


FIG. 295.—LATEST MODEL OF MICROSCOPE.

mirror should generally be used for low magnifications, and the concave mirror for high. Experience will demonstate the best method of operating the diaphragm in the individual case, which is also true of oblique illumination. This last is found necessary at times; it is accomplished by tilting the mirror laterally, or by the use of an apparatus specially designed for the purpose, and which is attached to most of the newer models of high-grade microscopes. The standard tube length is 170 mm., and the revolving nose-piece being 10 mm. more in length, the tube should be placed at the marking 160 mm.

The **microtome** is an instrument for making sections of the tissues for microscopic examination. It consists of a stage for holding the material to be cut, and a knife for making the sections. A perfect celloidin block for imbedding the tissues to be sectioned is also required. The stage of the instrument should be solid and immovable, and the knife heavy, sharp, and of sufficient length to pass evenly through the entire block when the knife is adjusted at the proper angle. A good instrument is that known as the Minot Precision Microtome; in addition to possessing the necessary features just described, this instrument is equipped with a micrometer screw controlled by an indicator that elevates the block, after each stroke of the knife, to the desired thickness of the sections to be made. In this way any number of sections of uniform thickness may be made, or the degree of thickness may be regulated to meet individual demands.

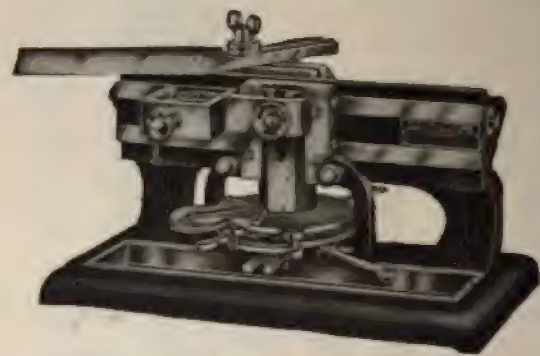


FIG. 296.—AUTOMATIC LABORATORY MICROTOME.

The **freezing microtome** resembles in principle the instrument just described, except that it is much simpler in construction, and that its use is limited to small, dense tissues. It is not, therefore, a necessary adjunct to the laboratory of the ophthalmologist, but because of its low cost, and from the fact that by

its means sections of certain tumors, such as some orbital growths, lid tumors, etc., can be made and examined during the

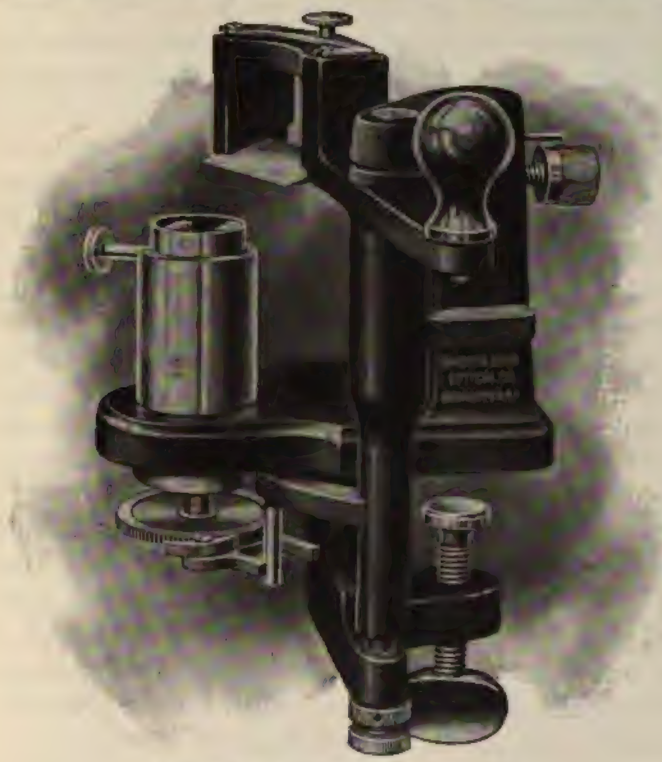


FIG. 297.—FREEZING MICROTOME.

operation without the loss of time necessitated by the various hardening and fixing processes, it is a desirable acquisition to the eye surgeon's armamentarium. A reliable instrument having the CO_2 freezing attachment is on the market. A large, sharp, very thin knife, about 19 cm. long and 3 cm. wide, is also required. The so-called "brain knife," having two cutting edges, has been found to serve the purpose very well.

FIG. 298.—DROP BOTTLE.

In addition to the instruments and apparatus described, there are required three or four teasing needles, a broad and a narrow section lifter, scissors, a pair of dressing forceps, a graduate

for measuring liquids, and six or more small, shallow staining dishes, preferably of glass, a large washing dish, stock bottles, etc. It is also well to have at hand two large bottles, fitted with a siphon, for holding alcohol and water; they will be found a very useful accessory and will save loss of time and material.

PREPARATION FOR EXAMINATION

Orientation of the Eyeball.—This is accomplished in various ways, and is of considerable importance, particularly in locating foreign bodies and intra-ocular growths. After the eyeball has been removed and placed in the fixing solution, a note should be made on the label as to the eye enucleated. Once this has been determined, the usual method of procedure is as follows:

For descriptive purposes the eye may be divided into three meridians—vertical, horizontal, and equatorial lines passing through such parts of the globe as the names indicate; e. g., a section of the eyeball passing antero-posteriorly through the horizontal meridian would be described as a horizontal meridional section. This section is the one most often employed for general purposes. Instead of passing directly through the center of the cornea and optic nerve, the writer makes the section a line or two above or below the meridian indicated, selecting the largest half of the eyeball for sectioning. The importance of this procedure will be seen soon after one has attempted section cutting with an indifferently successful celloidin block. In this way several sections through the nerve and that part of the cornea it is desired to study in sections may be spoiled without rendering the remainder unsuitable for microscopic examination. For determining the meridian with nothing but the identification of the globe to guide one, it will be remembered that the horizontal axis of the cornea is greater than the vertical, and that the section of the nerve is generally not transverse, but short on the side of the globe upon which the scissors entered the orbit (nasal or temporal) to complete the section. This method is practicable only when there is no deformity of the globe altering the relations just described, and should not be depended upon, especially when an intra-ocular growth or the presence of a foreign body is suspected. It is safer, then

fore, to indicate the landmarks by passing a suture through the internal rectus muscle, or touching a point in the vertical or horizontal axis with the caustic pencil. For locating intra-ocular growths and determining their form and extent, the writer uses a transilluminating apparatus, such as is employed at present for inspecting the interior of the globe *in situ*. This will prove a great help at times.

Examination of Fresh Tissues.—This method, aside from the fact that fresh preparations frequently present entirely different characteristics than when fixed and otherwise treated for general purposes, is valuable as an aid to the early diagnosis of growths, and especially for the differentiation of gliomata—pseudo-gliomata. A glioma presents an entirely different picture in the first state, and the cells can readily be differentiated from the leucocytes which form the contents of a pseudo-gliomatous eyeball. It is the writer's custom to make an immediate examination of all cases of suspected glioma. This is accomplished as follows: The eyeball is placed in a thin rubber bag and the opening closed with a rubber band. The whole is placed in a freezing mixture of salt and ice in which it is allowed to remain until it assumes a stony hardness, when it is removed and the eyeball sectioned in any manner desired. The cells clinging to the knife are then spread on a cover-slip, allowed to dry, and fixed to the glass surface by passing through the flame several times; a drop of Löffler's methylene-blue solution, or some other stain, is placed on the specimen, in which it is bathed for two or three minutes. It is then washed in water and, after pouring off the excess of fluid, the cover-slip is gently dropped on the glass side, pressure is made by means of a soft pad of bibulous paper, and it is placed under the microscope. If the preparation is found to be valuable and worth preserving permanently, the cover-slip may be gently pried off, the specimen allowed to dry, and a drop of Canada balsam placed upon the slide; the cover-slip is laid on this, and thus a permanent mount is secured. Although fresh specimens suffer somewhat from the freezing and thawing, and the method has been condemned by some writers, it will be found to be most practicable in the examination of gliomata, inasmuch as the ordinary pressure of the knife or scissors in sectioning an unfrozen specimen is generally

enough to disturb the soft, delicate, histologic relations [illegible] tumor mass which can be preserved by freezing. If the m[illegible] of drying on the cover-slip and passage through the flame [illegible] severe, and produces distortion of the cells, it is the writer['s cus]tom to place a small mass of soft tissue on a bit of bib[ulous] paper, which, after being immersed in the staining liquid [a] few moments, is likewise gently dipped in water; a cover-[slip] drawn across the surface of the stained mass, and the succe[ssive] steps of the procedure carried out as previously described.

The cells of harder growths, such as sarcomata, m[ay be] studied in the fresh state by tearing the tissue into small pa[rts] with needles, and the mass suspended in a drop of fluid; t[hen] spread upon the cover-slip, and the method proceeded wi[th as] before directed.

Examination of Liquids.—It is of interest in some ca[ses to] examine the fresh fluids of the eye—subretinal fluid exu[date,] fluid vitreous, etc. The plan adopted by the writer has be[en to] dry a portion of the sclera, make a delicate slit through th[e coat] with a sharp instrument, just enough to penetrate, the op[ening] being touched with the cover-slip and put aside for future [illegible] By a gentle sawing motion the knife is pressed farther unt[il the] vitreous cavity is entered, and then a platinum loop is [illegible] deeply into the opening, and a drop of fluid extracted and s[pread] upon the cover-slip. It is interesting to compare the two p[repa]rations, to determine if there is any difference between [what] might be subretinal fluid and what vitreous fluid. This m[ay be] examined without further preparation and before drying [has] taken place, or it may be fixed and stained as before dire[cted].

The practice of freezing the eyeball is not to be recomm[ended] except in certain cases which will be described farther on.

The Freezing Microtome and the Treatment of Frozen [Sec]tions.—As has been stated elsewhere, this method is appl[illegible] [illegible] those not more than 5 to 10 m[illegible] [illegible] The flat surface of the tis[sue] [illegible] the freezing stage of the m[illegible] [illegible]

rotated backward and forward, passing through the specimen until a small mass of sections are heaped upon the blade. These are removed by means of a small camel-hair brush dipped in 80 per cent alcohol. The mass is dropped into a dish of water, and, owing to the impregnation of the sections with alcohol, they will spread out quite flat upon the surface of the water, after which they can be readily handled. If some of the alcohol comes in contact with the specimen it will be necessary to freeze it again; thus as many sections as are desired may be made. A section should be lifted on the small section lifter or on a strip of fine tissue paper, and the remaining steps of the staining process completed, if possible, without leaving the instrument. This is accomplished with more ease than if the section is allowed to curl up, when it is spread out again only with difficulty. The procedure as just described is carried out by means of the microtome mentioned in the foregoing, which has a micrometer screw that can be adjusted so that sections of any desired thickness may be cut, the movement of the knife elevating the specimen after each section has been made. After the sections have been taken from the water on the lifter or on tissue paper they are placed in hematoxylin and overstained for from four to ten minutes. The remaining steps are as follows:

Wash in water.
Decolorize with acid alcohol.
Wash in water.
Brighten the blue stain in ammoniated water.
Wash in water.
Counterstain in eosin.
Dehydrate in absolute alcohol.
Clear in carbol-xylol.
Mount in Canada balsam.

Hardening and Fixing.—**Müller's Fluid.**—This method, although very valuable when properly employed, has long been popular in the laboratory, especially in that of the ophthalmologist. It is, nevertheless, but seldom used by the writer, who prefers the formalin method; he condemns it for the following reasons: The use of Müller's fluid as a hardening medium requires much more care, and a longer period of time is necessary to complete the process; by its use the tissues are rendered worth-

less for many special stains, a part of the structure nucleus of cells is destroyed, and it prevents the demons of karyomitotic figures. It also spoils specimens for bacter purposes. In its favor may be mentioned its slower pro hardening; eyeballs are not so apt to collapse, and it found of advantage in treating globes that have alrea lapsed, often filling out the eyeball by deeply penetrating sues, and by its exchanges of fluid those of the eyeball out while the Müller's fluid passes in.

Müller's fluid is composed of the following:

Potassium bichromate.......	10–12	parts;
Sodium sulphate	5	"
Distilled water	500	"

After enucleation the eyeball is immediately placed in a tity of fluid nine or ten times its volume, and the fluid cl for the first four or five days, or until it no longer b cloudy. It is important to have an excess of fluid and t the specimen in the dark to prevent the deposition of chr salts in the tissues. The specimen should remain in th for five or six weeks, at an ordinary room temperature, two weeks in an incubator the temperature of which sho about 39° C. After the hardening of the globe is comple specimen should be washed in running water for two d remove the excess of chromium, the presence of which tissues would further impair its staining properties. The ening process is then gradually completed in alcohol in t lowing manner:

Alcohol 70 per cent......	24	hours;	
" 80 per cent......	24	"	
" 90 per cent......	24	"	
" 95 per cent......	24	"	The globe is divi
" absolute.........	24	"	

Imbedding.

The Formalin Method.—This, the most valuable har method at our disposal, serves to fix the tissues very r and for this reason they should not be allowed to remain solution too long a period of time. It partially preserv

transparency of the cornea, although the lens becomes opaque. It does not spoil the tissues for most of the special stains, and it is easily prepared. The tissues retain some of their natural colors, so that this method is the most valuable for preparing tissues for both sectioning and macroscopic mounting. It does not destroy the form of the globe, although it has not the same power of restoring the form after collapse, as Müller's fluid has. It requires no washing in water, and, on the whole, will be found the most valuable method for all practical purposes. For general laboratory use the solutions are prepared in two strengths—5 per cent and 10 per cent—Schering's formalin and distilled water. Hardening in 10 per cent formalin is complete in twenty-four hours and in 5 per cent in forty-eight hours. In the latter strength, or somewhat weaker, the specimen may remain for a considerable period of time. For completion of the hardening process the specimen is taken directly from the solution and, without washing, is placed in 70-per-cent alcohol, after which the same method is pursued as described under Müller's fluid.

Division of the Hardened Eyeball.—For this purpose a very sharp brain knife is needed, and, after deciding upon the line of division, the globe is laid upon a pad of towels or soft paper. Assuming that the section is to be a horizontal meridional one, the knife is made to enter the nerve by a gentle sawing motion; after the knife has become engaged, the globe is lifted and inspected, to determine whether the prolonged cut will pass through the part of the eyeball desired. This point having been determined, the section is completed, stopping just before the position of the lens is reached, when the sawing motion ceases and the knife is pressed firmly through the lens, the sawing motion is then resumed and carried to completion. If the sawing motion is attempted through the lens, the lens being hard, the knife will be found to stick and the delicate attachments of the lens ruptured, producing dislocation of this body and destruction of the relations in these parts. The division of the globe into an anterior and a posterior segment is accomplished with greater ease, the same general rules being applied. In cases where the sclera is thin, the eyeball already partially collapsed, and the vitreous chamber empty or filled with fluid, considerable difficulty will often be found in making successful sections. It is impracticable,

however, to freeze the eyeball after dehydration by alcoh latter having a very low freezing point, and rehydration tissues defeating the object of hardening thoroughly befor tioning to prevent deformity, which is much more likely t place after the eyeball is opened; for the same reason only cases previously mentioned (intra-ocular growths, fresh etc.) it is recommended that the globe be entered befo hardening process is completed, when it is hoped to make microscopic sections, showing normal relations. Openi eyeball for macroscopic exhibition will now be described.

Mounting in Glycerin Jelly for Macroscopic Dem tion.[1]—The writer employs the following method, the jelly prepared as follows: Gelatin (best French), 1 ounce, is small strips and soaked in water for twelve hours; pour water and dissolve in the following solution: Glycerin, 8 c water, 8 ounces; egg albumen, 6 ounces. Thoroughly br in graduate with spoon, and mix with 3 ounces of the s just described, which should be hot when mixed, filter th flannel into the remaining solution and mix thoroughly; pl water bath, and after the boiling point has been reached, it to simmer without stirring for five minutes, or until albumen is coagulated. Filter through hot-water funn anything that will serve the same purpose, and add 30 r of pure formalin, a drop at a time, stirring after each d prevent lumps forming; then cool. This jelly is almost col transparent, and very firm, and does not melt at summer in fact, after the jelly is several months old it is melted witl culty, even by prolonged exposure to the heat of a water In cases where the tissues are thoroughly impregnated about 10 per cent formalin solution before mounting, the tional formalin causes the jelly to contract as its grows (possibly over a period of several months), squeezing the contained in it from its substance. This collects on the s in drops; it is, therefore, not advisable permanently to se lid of the cell until this complete contraction has taken plac should the cell be completely filled with the jelly, sufficient

[1] **Goldberg Method.**—"Report of the Committee on Exhibit of the logic Preparations at the Section on Ophthalmology," A.M.A., New O May 5–8, 1903.

being allowed for the water to collect. After this contraction has taken place it is impossible to melt the jelly even with the actual flame—it will burn, but not melt, and if it becomes necessary to remove the tissue, the jelly must be dissolved away. Tissues hardened in 5-per-cent or 10-per-cent formation solution, having remained in the solution several days, may be frozen, cut, and mounted without any further preparation. If tissues hardened by the other methods, after having passed through the alcohols, are placed in a 5- or 10-per-cent solution of formalin for twelve hours, their preservation in the jelly will be more complete and permanent. When the tissues are impregnated with the formalin solution, a capsule 5 or 6 mm. in thickness is formed around the eye, due to the hardening action of the formalin on the jelly. If the vitreous cavity is not already filled, it will be occupied by a mass of tough jelly that preserves the form of the globe. In any event, all alcohol must be removed from the tissues before mounting in the jelly, or air bubbles will form around the tissues and spoil the appearance of the mount. Eyeballs may be frozen, cut, and mounted after having remained in formalin solution for only twelve hours, thus preserving the first changes noticed.

To preserve a fresh specimen for macroscopic demonstration, to avoid the alcohol bleaching process, and to reserve the other half for microscopic sections, it is safer to place the half for macroscopic sectioning in 50-per-cent alcohol, then successively in 60-per-cent, etc., rather than to place it directly in 70-per-cent alcohol, as advised in the foregoing method. This slower dehydration process will prevent some shrinking of the tissues. The mounts are the ordinary cut-glass dishes with white porcelain covers sold for this purpose. The dishes are first sealed with white photographic paste (which allows the cover to be easily removed) until contraction has completely taken place. The water is then absorbed with blotting paper and the jar permanently sealed with xylol balsam. The additional advantages of this method, besides those just described, are that it acts as a preservative for the tissues, which can be removed from it within several months, or possibly longer, and cut and stained for microscopic study; it fixes the natural color of the tissues, and is easily prepared.

Imbedding Celloidin.—The celloidin used by the wri obtained in the form of shavings, and the mixture is prepa the following manner:

The specimen, after having undergone thorough dehyd by remaining finally in absolute alcohol for twenty-four and equal parts of absolute alcohol and ether for twent hours, is placed in a thin solution of celloidin. Unless de tion is perfect, it is impossible to obtain a good celloidin and without the latter good sections are impossible. The be should therefore realize the importance of this step in th cedure. The thin celloidin mixture is prepared by addi absolute alcohol and ether mixture to the stock solution loidin until the fluid is slightly sirupy. It is allowed to ren this mixture for three or four days, when it is placed in th celloidin. The thick celloidin may be of almost any cons —thin enough to pour, because if the saturation of the with thin celloidin is complete, that will be sufficient for block. After three or four days in the thin celloidin it is in the thick, which is contained in a flat-bottomed tubular men jar. The specimen is arranged at the bottom of t while immersed in the celloidin, with sufficient space arc to permit trimming after the celloidin has solidified. T containing the specimen is placed on a flat surface under jar, a glass cup, or a cover that will exclude most of tl and examined from time to time. The solidification of t loidin must not be too rapid, or air bubbles will forn enough celloidin must cover the specimen to allow for ev tion (about a centimeter). During all this time the sp should not be touched with the fingers, to avoid rehyd The specimen should be inspected at various times, and a as the celloidin is solid, a thin needle is pushed down the of the glass and gently worked around the entire block u is separated from the jar. It can then be easily shaken c gently striking the edge of the jar on the hand. The block is now placed in a solution of 75-per-cent alcoh which it is allowed to remain until the celloidin is of equa sistence throughout the entire block (about twelve hour an eyeball). The superfluous celloidin is then trimmed off. ing about 2 mm. all around the specimen, after which

mounted on the cutting base in the following manner: The base is preferably fiber block cut in various sizes. The specimen will be found to stick to this better than to stone or rubber, and to facilitate this feature, the surface of the fiber base may be stabbed several times with a knife point to roughen the surface and give better purchase for the celloidin block. The specimen, being trimmed, is dipped several times in equal parts of absolute alcohol and ether to remove the water from the surface, and, being held on a needle, is dropped on the surface of the fiber base, on which a layer of thick celloidin has been spread. After standing in the air for several minutes to allow some drying of the celloidin, the whole block is put back in the 75-per-cent alcohol solution, in which it is allowed to remain until the block is firmly fixed to the base (about two hours).

Section Cutting.—The celloidin block is screwed firmly in the compartment designed for it on the microtome, and set so that the knife will pass through the part of the tissue desired. The knife is adjusted so that it will pass obliquely through the entire specimen. The knife blade and specimen are covered with 75-per-cent alcohol, and then the blade is pushed over its track backward and forward through the specimen, or if the carriage of the specimen moves instead of the knife, the same procedure is followed with that, the micrometer screw being turned to drive the specimen upward to the desired height after each backward stroke of the blade or specimen, as the case may be. The section floating in alcohol is lifted from the knife with a fine camel-hair brush saturated with alcohol and transferred to a bottle containing 75-per-cent alcohol, in which it remains until staining. Before making sections through the tissue it is wise to have a thin layer of celloidin on the cutting surface, and make the first few sections pass through that.

Staining.—Two forms of stains will be described here — nuclear stains and contrast stains. The nuclear stains will include Delafield's hematoxylin, acid hematoxylin, and hemalum.

Delafield's hematoxylin is perhaps the most popular of these stains, and is the one most frequently used by the writer for general practical purposes. It is prepared as follows:

SOLUTION A:	Crystalline hematoxylin	4
	Absolute alcohol	25

SOLUTION B: Concentrated solution of ammoni: 400 c.c.

The solutions are mixed and exposed to light and : open vessel for four days, and then filtered. To this m added:

Glycerin	100 c.c
Methylic alcohol	100 c.c

After two days the whole is filtered. This stain impro age, and may be used in concentrated solution or dilu water.

Acid Hematoxylin:

Water	100	c.c.
Absolute alcohol	100	"
Glycerin	100	"
Glacial acetic acid	10	"
Hematoxylin	2	"
Alum in excess.		

The mixture is filtered and exposed to light until it dark red in color. This stain may also be used concent diluted with water.

Hemalum.—One gram of hematin is dissolved by he c.c. of 90-per-cent alcohol, and mixed with a solution oi of alum in a liter of distilled water. A crystal of thymol to prevent the growth of fungi.

The first two stains described will overstain the tiss which it must be washed in water and decolorized in acid Hemalum is not so likely to overstain, and is, therefor able for quicker work, but will not give so brilliant resul other stains.

Staining with Delafield's Hematoxylin and Acid Hemat The specimen is removed from the jar on a fine br dropped in water, when it will be found to uncurl and fl lently about on the surface of the water; when this actior

it is conveyed by means of the broad section lifter to the stain, which is contained in a small dish, there being enough to cover the section. It is allowed to remain in this for ten minutes, and is washed in water until no more color is given off; it is then decolorized in acid alcohol (concentrated HCl, 1 part; alcohol, 90-per-cent, 100 parts). When the celloidin is decolorized and the stained tissue has turned pinkish blue, it is again washed in water and transferred to water rendered slightly alkaline by the addition of a few drops of ammonia water; here it remains until the tissue is bright blue; then it is again washed in water and may be dehydrated, cleared, and mounted or counterstained. If it is mounted without counterstaining it is removed from the wash water and placed in 95-per-cent alcohol for about five minutes. From now on it must be handled very carefully, as it is exceedingly apt to be torn if it once becomes folded. For this reason, instead of using the section lifter, the section is floated on a strip of tissue paper of the same width as the section (cigarette paper), lifted from the alcohol by holding the dry end of the paper in the fingers; it is dipped in absolute alcohol for a minute or two, and then in the clearing oil (xylol, 3 parts; carbolic acid, 1 part). It clears very quickly if dehydration is complete; now the paper holding the section is inverted over the slide, on which it is laid, the section against the slide. The tissue paper will strip off easily, leaving the section perfectly flat on the slide. The excess of clearing oil is removed with a pad of bibulous paper pressed against the section, as one would blot up ink. A drop of xylol balsam is placed on it, and over this the cover-slip.

Hemalum requires no decolorization, but in other respects the procedure is the same as that just described.

Counterstaining in Eosin.—After decolorization, washing, and treating with ammoniated water and washing, the specimen is placed in a dilute solution of eosin (a few drops of the concentrated alcoholic solution in water). It is slightly overstained for five or ten minutes (until the blue tissue is distinctly pinkish blue), and is then removed to 95-per-cent alcohol and treated as before described. If it is found that the alcohol removes too much of the counterstain, the 95-per-cent alcohol may be slightly colored with the eosin. After this stain, the nuclei of

or twenty minutes), washing in water, decolorization in acid alcohol, and washing are conducted in just the same manner as in the other methods. Then the section is stained for about one minute in a mixture consisting of a saturated aqueous solution of picric acid to which a few drops of a saturated aqueous solution of acid fuchsin have been added before use. It is then washed for a minute or two (or longer if the fuchsin stain is too intense), alcohol, 95 per cent, absolute alcohol, carbol-xylol, and xylol balsam.

PATHOLOGY

Inflammation.—The first change observed in an inflamed part is a slowing of the blood current, so that in the venous and capillary vessels the peripheral zone of plasma disappears and is replaced by white blood-cells. This phenomena is purely of a

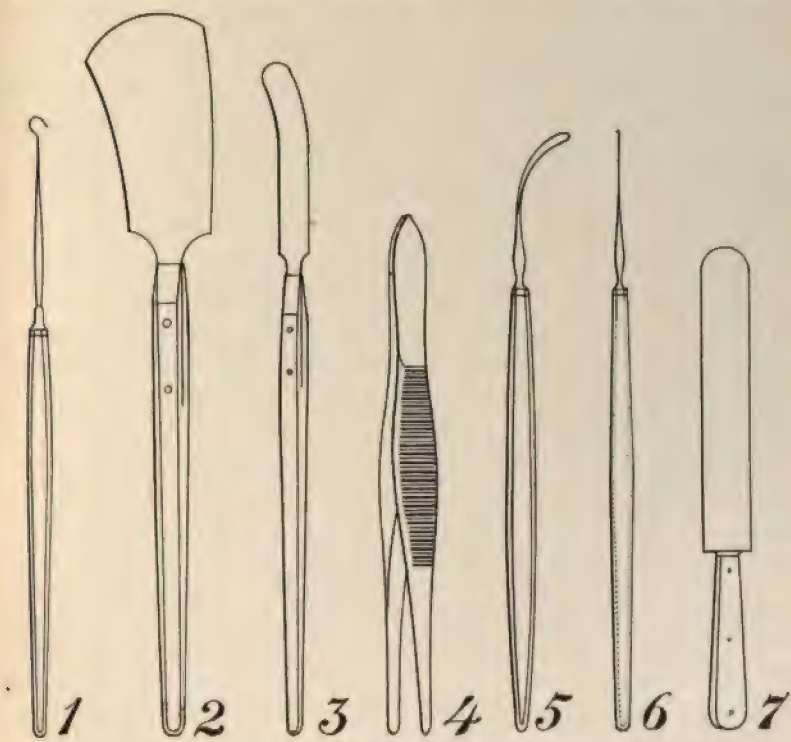


FIG. 299.—LABORATORY INSTRUMENTS.

1. Hooked needle. 2 and 3. Section lifters. 4. Tissue forceps. 5. Spatula. 6. Straight needle. 7. Brain knife.

physical nature, because it can be demonstrated that whenever corpuscular elements are suspended in a fluid that circulates in closed system of tubes, slowing of the current causes the peripheral drifting first of the lighter elements, and, if the veloci is still further diminished, that of the heavier elements.

The leukocytes, by reason of their peculiar nature, adhere the inner wall of the endothelial tubes, singly or in small grou finally becoming flattened against the inner surface of the vess wall. The cell then sends out small protoplasmic processes pseudopods, which penetrate the vessel wall, and gradually wo their way through. When the extremity of the process reac the outside of the wall, it swells out in the form of a button, a ultimately draws the entire cell through the wall. If the velo of the blood is still further diminished, the erythrocytes may a drift to the periphery, and the entire lumen appears to be den packed with red and white blood-cells. Red blood-cells may a be forced through the walls from the increased pressure.

The cornea has long been recognized as a suitable struc for observing inflammatory phenomena. During an inflam tory process, the result of a foreign body, an injury, or an in tion, the escape of leukocytes takes place from the vessels at limbus, the episcleral, and the conjunctival vessels, whence t travel through the system of intercommunicating spaces in substantia propria. The protoplasmic bodies of leukocytes divided into many forms, according to the granulations t present. The so-called neutrophilic leukocytes are compose a protoplasm that contains very minute granules, recogniz only in the recent state. The eosinophile leukocytes con large granules that stain deeply with the acid anilin dyes, e cially with eosin. Basophile cells, or mast cells, contain la granules that show an affinity for the anilin dyes, such as met lene-blue and gentian violet. Large mononuclear leukocytes characterized by large protoplasmic bodies and circular nuc containing an abundance of chromatin. Lymphocytes are sm spheric bodies with a narrow protoplasm and a deeply stain nucleus, which fills almost the entire cell. According to the fo of their nuclei they are known collectively as polynuclear leu cytes, being generally supplied with two, three, or four nuc that may be horseshoe-shaped, biscuit-shaped, sausage-shap

etc., and being frequently connected by fibrillary bridges, or so-called fragmented nuclei.

Inflammation may be followed by the formation of new tissues (regeneration) which sometimes results in the complete restoration of the destroyed part. In order that this may occur, however, the formation of new cells must be begun and continued by the corresponding cells in the surrounding tissue, until the defect has been compensated for. The universal law is, that the new formation begins always and exclusively in the same kind of tissue as that attacked. It should be remembered, however, that within the group of connective tissues a mutual substitution of one kind of cells for another may take place—i. e., connective tissue may be formed from endothelial cells, and cartilage or bone from connective tissue cells, but connective tissue is never capable of producing epithelial tissue, or *vice versa.* Briefly, in the formation of connective tissue as it appears, for example, in a fresh wound of the skin or mucous membrane, we observe in succession the following phenomena: First, a circumscribed necrosis of the old tissue appears at the wound edges; this is filled up and bridged over by fibrin; at the same time there appear, usually within the meshes of the fibrin, numerous polynuclear leukocytes that have escaped from the blood-vessels around the margin of the wound. Gradually new cellular elements make their appearance and grow into the fibrin, which, for the most part, they consume as they continue to grow. These cells are spindle-shaped or polyhedral, contain a fair amount of protoplasm, and are derived from the old connective-tissue cells (fibroblasts). In addition, plasma cells are found; these, either as small mononuclear leukocytes or as larger plasma cells, with granulated protoplasm and sometimes with several nuclei, produce the so-called small-cell infiltration of the granulation tissue. The evolution of the cellular material is accompanied by the sprouting of endothelial cords, which can be formed from tissue of their own kind, and are later hollowed out by the inflow of blood.

The regeneration of epithelium in the cornea takes place in the following manner: Superficial wounds, involving only the epithelium, are usually completely covered with epithelium in twenty-four hours. If the wound is deeper, penetrating the sub-

propria, the defect is first filled with a deposit of ... from the aqueous humor. This is bridged over ... epithelium, which dips into the wound in the ... This downward growth persists after the fib... replaced by granulation tissue and the continuity ... has been restored. It is also common to find ... leukocytes between the epithelial cells, a... epithelial cells, especially in the cylindric ... The downward growth of the epithelium which ... is sometimes so extensive that single epithel... even completely cut off from their surroundings. ... connected with the surface and are the res...

Fatty Degeneration.—The affected cells are cro... droplets that, in the early stages, are minute and ... certain relations to the normal structure of the ce... protoplasm of the cell is replaced by a mass of det... of granules of fat. Fat-granule cells are also ... are wandering corpuscles that have imbibed th... fatty degenerative processes and are the cells tha... characteristic white patches of albuminuric re... glaumata and when pressure has been severe, f... areas are seen; these may be differentiated ... areas by the needle. In the former the ... and cheesy, whereas in the latter a gritty ... perceived.

Fat granules in the fresh state are seen under the ... bright, colorless bodies, exhibiting a dark outline ... In specimens treated with alcohol this app... presented, because of the dissolving action of th... cells are stained black with 1-per-cent osmic-aci... deep violet, when treated with iodin violet. In ... observe the change in arcus senilis. The oil drops ... in two ways—in the direction of the lamellæ of the co... they have replaced, and in the interstices as a fatty dep... The slight elevation of the cornea over an arcus is caus... condition.

Cholesterin, or fat crystals, are frequently found in the fluids ... eye. When present in the aqueous or vitreous humor,

normal formation of mucus in the mucous gl
epithelium the formation of mucus normally, as
logically, takes place through the agency of the s
cells. During secretions these cells become swolle
mation of mucus takes place in the upper half of t
the contents are discharged, the cell may regain its
or die. In pathologic conditions of the conjun
chronic conjunctivitis, trachoma, and on the surf
mata, the goblet cells are largely increased in
presence of mucus is demonstrated by the mu
mucin is not coagulated by boiling; it is precipit
acid and dilute mineral acid. With hematoxylin
stances usually stain a pale grayish-blue to an inte
flattened nucleus is seen lying against the wall
part of the cell. It is well stained with Van Gieso

Hyaline Degeneration.—Hyaline substances
ized by their homogeneous character and high ref
Hyalin is not coagulated by acids. It remains
water and salt solution and in alcohol and ether, l
ammonia. It stains readily with carmin and pic
so by hematoxylin. It does not give the iodin
iodin, although it resembles amyloid material and
associated with it. Hyaline degeneration may o
form of chronic inflammation, and as a natural
age. It may be found diversely in arcus senilis an
papilla. It is very commonly found in the hyaloid

occur in the connective tissue of the ciliary processes and in the walls of their blood-vessels are characteristic.

Amyloid degeneration is characterized by the deposition in the tissues, especially the connective tissue of the vascular system, of an albuminoid substance, which, under the microscope, presents a peculiar homogeneous appearance. When well advanced, it may be seen with the naked eye as a solid, dry, waxy, transparent, bloodless material. It is generally seen in homogeneous shining patches under the microscope. It is found typically in the conjunctiva, generally as a sequel of trachoma when it produces the formation of tumorlike masses. It is generally claimed, from all that is known of amyloid degeneration, that both its formation and its distribution are extracellular—that is to say, the cells of an organ are never attacked by the degenerative process, and the changes they show are all secondary. Amyloid material presents the iodin reaction when treated with Lugol's solution diluted with three parts of distilled water. The sections are stained for five minutes, washed in water, and examined in glycerin. The amyloid areas are stained brownish-red, the unaffected tissue remaining a bright yellow. When treated with tincture of iodin until all the normal tissue is stained an intense straw-yellow, the parts affected with amyloid degeneration appear first as brown, then brownish-red, and later as red dots and lines. In severe cases, if the treatment is continued, amyloid material often takes a violet tint, according to the stage of the degeneration. The addition of dilute sulphuric acid (1-per-cent solution) to the preparation gives a dark violet or black stain. The substance is stained rose-red by hematoxylin-eosin, brownish-red by Van Gieson's stain, ruby-red with methyl-violet, and reddish-violet with iodin-green.

BACTERIOLOGY

The instruments needed for laboratory use, besides those described under the head of Pathology, are: Cover-glasses and slide-holders, platinum rods, an old von Graefe cataract knife, and dropper bottles for holding stains. These instruments will serve for ordinary office purposes, where rapid examinations of smears must be made. For the finer technic, involving cultivation, etc.,

there will be required in addition an incubator, test-tubes, Petri dishes, and, for the preparation of culture-media, various cooking utensils. These last, however, are not essential, since culture-media may be purchased from the various biologic laboratories or will be supplied by the health departments of most large cities.

The **incubator** is a copper device containing an ovenlike chamber, surrounded by double walls between which is placed the hot water that maintains the temperature of the inner chamber. It is equipped with an adjustable burner for regulating the size of the flame, connected with a thermo-regulator for controlling the heat of the chamber, and a thermometer that indicates the temperature of the compartment.

Method of Procuring Material.—*From the Conjunctival Secretions.*—The loop of a platinum rod having been subjected to the flame of the spirit lamp or Bunsen burner until a white heat has been obtained (this is necessary to insure a sterile instrument), is dipped deeply into the *cul-de-sac*, the lower lid being drawn down. The material obtained is then spread upon the cover-slip, dried, passed through the flame several times to fix the smear to the glass, and stained. If the secretion is profuse and is forming rapidly, it is a good plan first to flush the eye with sterile water or salt solution, and then, when the discharge has accumulated again, to secure the specimen. In this way it is sometimes possible to obtain a pure culture of the offending organism, and prevent the contamination that so frequently takes place and complicates the diagnosis when two or more organisms are present.

From the Cornea (Ulcers).—Here again it is best to flush the eye with sterile water or salt solution to prevent contamination, after which the lids are separated and the point of a sterile cataract knife or the flattened and rounded end of a platinum rod is dipped deeply into the floor of the ulcer. The material secured is spread upon the cover-slip, dried, fixed in the flame, and stained. The platinum rod or knife must be sterilized in the flame both before and after using.

Methods of Cultivation.—Fluid culture-media are inoculated with a loopful of pure culture. Gelatin and agar stab cultures are made with a straight needle, only a single stab being made in

each tube; it should, however, extend almost to the bottom of the tube. Agar and gelatin streak cultures are inoculated by means of a gentle, superficial stroke over the surface with the platinum loop.

Gelatin Petri-dish Cultures.—This method has for its purpose the isolation of certain bacteria in pure culture. The gelatin is melted in 3 tubes, and then allowed to cool to 30° C.; a loopful of culture is introduced into one of the tubes and well mixed. One or two loopfuls of gelatin from this first tube are carried to a second tube, and from this, after mixing, 2 or 3 loopfuls are again transferred to a third tube. The contents of each tube are poured into separate sterile dishes, the cover being quickly raised, but not entirely removed; after pouring, the plates are rocked gently to and fro, in order to distribute the gelatin as uniformly as possible. The plates thus prepared are then placed in the culture chamber at a constant temperature of 22° (or at room temperature), and after two or three days the individual colonies that have developed are studied macroscopically, or with slight magnification, the dish being placed on the stage of the microscope and the low power used.

Agar-plate cultures are prepared in the manner just described. The agar must not be too cool when it is poured into the dish or it will solidify at once, forming an uneven surface. On the other hand, if it is too hot, the bacteria will be destroyed and the specimen will be useless.

Nutrient Media.—The following nutrient media, although by no means applicable to every case, will be found of value for most practical purposes:

Nutrient Agar.—To 1,000 c.c. of meat infusion 10 gm. of finely cut agar are added and the mixture boiled in a glass flask over an open fire for one hour until solution is complete; the evaporated water is then replaced, and 10 gm. of peptone and 5 gm. of sodium chlorid are added. After again heating in the steam chamber, the fluid is neutralized and filtered by means of the hot-water funnel, poured into tubes, and sterilized. (*Meat infusion* is prepared by boiling 500 gm. of lean beef in 1,000 c.c. of water in an enameled pot over a flame for half an hour, and then filtered.)

Glycerin Agar.—To the prepared nutrient agar 5 per cent of

glycerin is added, after which it is poured into tubes and sterilized.

Blood Serum.—Blood obtained from slaughtered animals under proper precautions is poured into well-cleaned glass cylinders and placed in a refrigerator for twenty-four hours. The serum is then removed with large sterile pipettes and placed in flasks, adding 1 per cent of chloroform. They should be allowed to stand for several weeks, being occasionally shaken. Before using, the flasks should be placed in the incubator for a few days to insure complete evaporation of the chloroform. The fluid mixture may be used, or it may be solidified at 65°.

Löffler's Blood-serum Mixture for Cultivating Diphtheria Bacilli.—Three parts of beef or sheep serum are mixed with 1 part of veal bouillon, containing 1 per cent of grape sugar, 1 per cent of peptone, and 0.5 per cent of sodium chlorid.

Stains.—*Löffler's Methylene-blue.*—To 100 c.c. of water is added 1 c.c. of a 1-per-cent solution of potassium hydroxid and 30 c.c. of a concentrated alcoholic solution of methylene-blue. The staining property of the dye is intensified by the addition of the alkali. Stain for from three to five minutes, wash in water, and mount. The bacteria and nuclei of the cells are stained blue.

Gram's Stain.—1. Stain with Ehrlich's solution for from three to five minutes. This is prepared as follows: To 100 c.c. of anilin water (which is prepared by shaking 10 c.c. of transparent anilin oil with 100 c.c. of water in a test-tube and filtering through fine filter paper moistened with water) 11 c.c. of a concentrated alcoholic solution of gentian violet (stock solution) is added. This solution does not keep well.

2. Wash in water.

3. Differentiate with Gram's iodin solution for two minutes (tincture of iodin, 1 part; potassium iodid, 2 parts; distilled water, 100 parts).

4. Decolorize with absolute alcohol until no more color is given off (usually one or two minutes).

5. Wash in water.

6. Counterstain with aqueous fuchsin (a drop of a concentrated alcoholic solution of fuchsin in a test-tube of water) for twenty or thirty seconds.

7. Wash in water.
8. Mount.

Some organisms retain the deep violet color; these are known as positive. Others lose the stain and are colored red by the fuchsin; these are known as negative.

Neisser's Stain for Diphtheria Bacilli—Solution No. 1

Alcohol (95 per cent)	20 parts.
Methylene-blue (Grubler)	1 part.
Distilled water	980 parts.

Solution No. 2

Bismarck brown	1 part.
Boiling distilled water	500 parts.

The cover-slip smear is stained with solution No. 1 for from two to three seconds.

Wash in water, and then in No. 2 solution for from three to five seconds.

Wash and mount.

A concentrated stock solution is prepared by pouring absolute alcohol upon the pulverized dyes in bottles, and, after shaking and allowing them to stand for a few hours, they are filtered.

Better results are obtained from staining a longer time with weak solutions than a short time with strong solutions.

Mounting.—After the smear has been prepared (spread, dried, and fixed to the cover-slip or slide) it should be placed in the holder and a drop or two of the stain poured over it. After the staining process is completed and the specimen has been finally washed in water, it may be mounted in one of two ways: The wet cover-slip (smear side down) is placed on the slide and a pad of bibulous paper is pressed over it; this will absorb the excess of water and cause the cover-slip to adhere to the slide. The surface of the cover-slip is dried and a drop of cedar oil put upon it, when it is ready for the microscope. If the examination reveals anything of special interest and the preparation is worth saving, the cedar oil is gently wiped off, the cover-slip pried free with the point of a needle and allowed

to dry in the air, after which it is permanently sealed to the slide by means of Canada balsam. If the examiner prefers to mount at once in balsam, after the final washing a pad of bibulous paper is pressed over the cover-slip (smear side up), dried, and mounted in Canada balsam as just described.

Staining Bacteria in Tissues.—The sections are taken from the alcohol and stained in Löffler's methylene-blue solution for from five to thirty minutes. They are then placed in 1-per-cent acetic acid for a few seconds, and, after differentiation, are passed through alcohol and carbolxylene and mounted in balsam. It is necessary to determine how long the acetic acid may be allowed to act, and the dehydration in alcohol must not be prolonged any longer than is essential. The bacteria should be dark blue, the nuclei somewhat lighter, and the protoplasm pale blue.

In considering the bacteria most frequently concerned in the production of eye inflammations, it has been the writer's aim to treat the subject in as simple and concise a manner as possible. For this reason only those organisms that, in his experience, have been encountered with sufficient frequency to warrant designating them the "bacteria of the eye" will be here considered. The list given by no means includes all the bacteria concerned in eye inflammations, but it is the writer's belief that with a working knowledge of the few here described, successful examinations of the secretions of the eye can be conducted in the physician's office.

The nomenclature of eye bacteria is somewhat distinctive, and consequently may prove confusing when compared to general bacteriologic nomenclature. It is therefore necessary, for purposes of elucidation, to review the classifications as they occur in most text-books, and to make further subdivisions according to their standing in bacteriology of the eye.

It will be remembered that bacteria are divided into two general classes: (1) the *saprophytes*, or those that live on dead organic material; (2) the *parasites*, or those that obtain their nutrition from living organic substances. It is to the second class, or parasites, that eye bacteria belong. This class is made up of three families: *Coccaceæ*, a spheric or oval bacteria, and *Bacteriaceæ* (*Bacillaceæ*), rod-shaped organisms. With the third

family, *Spirillaceæ*, we are not concerned, as organisms of this family have no representatives among the so-called eye bacteria. According to their standing in bacteriology of the eye the parasites may be divided into: *Pathogenic*, which organisms are not found in the normal conjunctival secretions, and which, when introduced, produce a contagious and specific inflammation; *non-pathogenic*, which may be found in the normal conjunctival secretions, and which produce inflammations only under certain conditions. According to their reaction to the Gram method of staining they may be divided into *positive*, those which retain their blue stain after decolorization, and *negative*, those which lose their blue stain after decolorization. In the family of *Cocci* we find the Staphylococcus pyogenes, aureus, and albus, Streptococcus pyogenes, Diplococcus lanceolatus, and gonococcus.

In the family *Bacilli* we have the diplobacillus of Morax-Axenfeld, the Koch-Weeks bacillus, diphtheria bacillus, and xerosis bacillus.

The following classification is arranged for simplicity of differentiation, and, in the sense intended, applies only to the bacteria of the eye. Those classified as nonpathogenic and positive to Gram's stain are not nonpathogenic in the strict sense of the term, but as used here the term implies that the organisms may occur in health, but are capable of becoming pathogenic under certain conditions, as in injury to the eye, lowered vitality of the individual, climatic changes affecting the virulence of the organism, chronic inflammation, etc. Those classified as pathogenic and negative to Gram's stain are not found in health, and when introduced into the eye produce a specific and contagious inflammation.

Pathogenic and negative to Gram's stain.	Diplobacillus of Morax-Axenfeld. Gonococcus. Koch-Weeks bacillus.
Nonpathogenic and positive to Gram's stain.	Diphtheria bacillus. Xerosis bacillus. Staphylococcus pyogenes. Streptococcus pyogenes. Diplococcus lanceolatus.

In addition to those mentioned, the following bacteria are also occasionally found: Bacterium coli, Bacillus pyocyaneus, Ozena bacillus, Friedländer's pneumobacillus, and other organisms of less importance.

Diplobacillus of Morax-Axenfeld.—This organism, which is the causative factor in producing subacute catarrhal conjunctivitis, is pathogenic for man, but not for animals. It is a large organism, averaging 2 μ in length and 1 μ in width, although small diplobacilli are sometimes seen; these are probably younger forms. The organisms are generally arranged in pairs, although long and short chains are also found. The ends of the organisms are slightly rounded and generally of the same thickness as the remainder of the cell. They are usually found free in the secretions in great numbers. They stain with the anilin dyes, the line of separation between the individuals being distinct; they are negative to Gram's stain, and the growth is abundant on alkaline solidified blood serum only at or near the body temperature. The growth appears in the form of small transparent colonies that, from their liquefaction of the serum, gradually sink below the surface.

Gonococcus.—The Micrococcus gonorrhœæ occurs generally in the form of diplococci, having an unstained division or interspace between the two concave surfaces that face each other, this giving them their characteristic kidney-shaped appearance, the line of separation being unstained. They are generally arranged in irregular groups, and are seen on and in the pus cells of the discharge. The older cocci lengthen, then become constricted in their middle portion, and finally divide, forming new pairs. According to their stage of development they are from 0.8 μ to 1.6 μ in length and from 0.6 μ to 0.8 μ in thickness. The gonococcus stains readily with the basic anilin dyes; Löffler's methylene-blue is one of the best staining agents for demonstrating its presence in pus, for, while staining the gonococcus deeply, it leaves the cell protoplasm but faintly stained. Fresh cultures and recent infections are negative to Gram's method, the removal of the stain in old cases not being so certain. The decolorized gonococci are counterstained with aqueous fuchsin, exhibiting a beautiful red contrasting with the blue of the nucleus, which serves to distinguish them from the so-called

pseudo-gonococcus of follicular catarrh, which organism is positive to Gram's stain. Cultivation is difficult; it grows best on human blood serum (1 part added to and mixed with 2 parts of melted 5-per-cent glycerin nutrient, 1.5 per cent agar having a temperature of 55° to 60° C.). At the end of twenty-four hours the colonies appear as a delicate, translucent growth, finely granular, with slightly scalloped margins. It has but little resisting power to outside influences, being destroyed by weak disinfectant solutions. When spread in thick layers on linen, however, it has lived for forty-nine days. It is killed at a temperature above 42° C. The conjunctiva is more susceptible to gonorrheal infection in early childhood than in later life. It should be borne in mind that there appears to be no limit to the time at which infection from the urethra may take place, twenty and even twenty-five years having elapsed in some cases between urethral and conjunctival infection.

Koch-Weeks Bacillus.—In this country the organism occurs epidemically, especially during the spring and fall months, and appears to be peculiar to certain localities. In purulent secretions it occurs in the form of a small, slender organism, not unlike the influenza bacillus, but somewhat longer. It varies in length from 0.5 to 1 μ or even 2 μ, the longer forms being apparently the union of threadlike filaments. The ends are rounded and their width is constant. They are easily distinguished from the diplobacillus by their size. This bacillus is responsible for acute contagious catarrh, and is generally found associated with the xerosis bacillus or the staphylococcus. The organisms are frequently observed in the cells of the discharge and lying free in the secretion. While they do not stain readily, this is best accomplished with dilute solutions of Löffler's methylene-blue or dilute solutions of carbol-fuchsin. Cultivation is difficult; the best culture medium is either serum-agar or a mixture of glycerin-agar and ascitic fluid, 2 to 1, in which, after forty-eight hours in the incubator, it occurs as moist, transparent, shining drops or points, which, under the low magnifying power, resemble small gas bubbles. The colonies have a tendency to coalesce. In culture media the organisms die rapidly, seldom living longer than five days. They resist a temperature of 50° for ten minutes, but cannot resist drying for any length of time. They are nonpathogenic for ani-

mals, but man is extremely susceptible, some persons being more so than others. The only organisms for which it is likely to be mistaken are the so-called influenza bacillus of conjunctivitis and the pseudo-influenza bacillus of Zur Nedden; clinically, however, they produce different symptoms.

Diphtheria Bacillus.—This organism possesses a great variety of characteristics. In diameter it varies from 0.3 μ to 0.8 μ, and in length from 1 μ to 6 μ. It occurs singly and in pairs, and sometimes in chains of three or four. It is straight or slightly curved, swollen or pointed at the end, and swollen in the middle portion. The organisms taken from the same individual frequently vary in size and shape, especially when associated with other bacteria. It stains readily with the ordinary anilin dyes, but best with Löffler's methylene-blue, and is positive to Gram's method. In serum cultures they stain in an irregular characteristic way—they do not stain uniformly—giving them a segmented appearance, some portions being more deeply stained than others. The same segments that stain deeply with methylene-blue are further intensified in color by the Neisser stain, when the organism will either appear to be entirely brown, or will show at one or both ends a dark-blue round body. With characteristic diphtheria bacilli, taken after from twelve to eighteen hours' growth on serum, nearly all will show the blue bodies, whereas in the case of the pseudo-organism few of the bodies will be seen. It grows best on Löffler's blood-serum mixture, appearing, at the end of from eight to twelve hours, as pearly or yellowish-gray slightly raised points. They do not liquefy the serum, and the growth is more abundant than the xerosis bacillus, with which it is frequently associated and for which it is likely to be mistaken; it should be remembered, however, that Neisser's granules are not as abundant and do not appear so soon. The organism is pathogenic for man and animals, producing death with characteristic lesions. It is capable of producing diphtheric conjunctivitis, but is also found in some of the more superficial forms, such as croupous. This is probably due to a mixed infection with the staphylococcus or streptococcus, with which it is so often associated, and which appears to determine the severity of the process. When found associated with the streptococcus the most severe type of the disease may be considered present—

even more severe than with the pure infection. It is also capable of producing simple catarrhal conjunctivitis and may be found in health.

Xerosis Bacillus.—This so closely resembles the diphtheria bacillus that it is often mistaken for it. It grows especially in short forms. The growth on Löffler's serum is dry and more scanty than that of the diphtheria bacillus, and still slower upon glycerin-agar. When grown upon Löffler's serum at 35° for from nine to twenty-four hours, there are none or but a few Neisser's granules. It stains with the ordinary anilin dyes and is negative to Gram's method.

Although this organism has received considerable attention at the hands of investigators, there still seems to be some doubt regarding its standing in bacteriology of the eye. It is undoubtedly present in a great variety of pathologic conditions—sometimes alone, but more often associated with other organisms—and is also frequently found in the healthy eye. Hala would look upon it as the cause of chalazia in the great majority of cases, whereas Gelpke [1] has isolated an organism the cause of a specific inflammation that he describes as a "catarrhal swelling," especially characterized by a bluish-red discoloration and swelling of a fold of conjunctiva, the formation of a fibrinous exudate, great pain and photophobia, together with constitutional symptoms. He called the organism Bacterium septatum Gelpke, believing it to be a new variety in spite of its great similarity to the short xerosis forms. Other investigators, however, believe there is nothing to distinguish it from the xerosis bacillus.

Diplococcus lanceolatus (Pneumococcus).—As its name would imply, this organism occurs as spheric or oval cocci, generally joined in pairs, pointed at the free ends, the united ends being broader. It sometimes occurs in longer or shorter chains, consisting of from three to six or more segments and resembling the streptococcus. The organisms are found rarely in the conjunctival secretions, being surrounded by a capsule, which can be demonstrated by special methods of staining. They stain well with the anilin dyes and are positive to Gram's method. Cultivation is difficult and requires frequent transplantation, best on

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[1] "Bacterium Septatum," etc., Karlsruhe, 1898.

a neutral or alkaline medium. Löffler's blood-serum mixture is a good medium, the organism occurring on this as a slimy, almost transparent growth. It is found in the normal conjunctival secretions, and is capable of producing acute contagious catarrh, epidemic in character and peculiar to certain localities. It is occasionally the cause of ophthalmia neonatorum and panophthalmitis. Its relation to corneal ulcers is very interesting, it having been found by certain investigators, notably Uhthoff and Axenfeld, to be the cause of a large proportion of cases of serpiginous ulcer.

Staphylococcus pyogenes.—A small spheric organism having a diameter of from 0.7 μ to 0.9 μ. It occurs as a solitary organism, or in pairs, in short chains of three or four elements, in groups of four, but more commonly in irregular masses resembling clusters of grapes; hence the name, staphylococcus. It stains readily with the anilin dyes and is positive to Gram's method. It grows best at a temperature of from 25° to 35° C., and is easily cultivated on all the ordinary laboratory media, but best if these are slightly alkaline. Growth on gelatin occurs within forty-eight hours as punctiform colonies which, under the low power, appear as circular disks of a pale-brown color with a smooth border. From a liquefaction of the media the colonies sink below the surface and later become confluent. It is a very resistant organism, and has been known to live for weeks and even months in dried pus. It is also found living in the air. It occurs in the normal conjunctival secretions, but especially in inflammations of the lid margins. It may be responsible for simple catarrh, pseudo-membranous conjunctivitis, dacryocystitis, panophthalmitis, and many forms of corneal ulcers aside from serpiginous ulcer.

Streptococcus pyogenes.—This organism occurs in the form of spheric or oval bodies, slightly larger than the staphylococci, varying from 0.4 μ to 1 μ in diameter. They generally form chains of 8, 10, 20 or more segments, being often, however, joined in pairs. They stain readily with the anilin dyes and are positive to Gram's method. They grow readily on ordinary culture media; not so abundantly, however, as staphylococci, the most favorable temperature being from 30° to 37° C. An excellent medium is solidified blood serum, in which they appear, at

the end of from twelve to eighteen hours, as tiny grayish colonies. The organism is found in the normal secretions. It is capable of producing two varieties of conjunctival inflammation—the simple catarrhal and the pseudo-membranous. The simple catarrhal form (Parinaud's conjunctivitis) is a rare variety, occasionally unilateral, and often described as lacrymal conjunctivitis, owing to the associated dacryocystitis. Although streptococci were found by most observers, it cannot be positively stated that they are the sole etiologic factor. The pseudo-membranous form is of more frequent occurrence, and, by giving rise to ulceration of the cornea, may result in loss of vision. Endogenous streptococcic infection has occurred in new-born infants, a fatal termination being reported in all cases.

This organism, as previously stated, is responsible for many corneal ulcers, and when associated with other organisms generally adds to the severity of the condition.

FIG. 300.—SLIDE FORCEPS.

In addition to the organisms just described, we find, occurring with less frequency, the following: the Bacillus pyocyaneus, frequently united in pairs or in chains of from 4 to 6 segments, and sometimes in long threads or twisted spirals. It grows well on gelatin, stains with the ordinary anilin dyes, and is negative to Gram's method. The Bacterium coli: Short rods with rounded extremities, sometimes almost spheric, and occasionally occurring in chains. Stains with the ordinary anilin dyes, and is negative to Gram's method. Grows well on all ordinary media.

In keratitis a large variety of organisms have been found. Of the common affections, only one organism can be looked upon as a causative factor with any degree of certainty. This is the Diplococcus lanceolatus, the cause of serpiginous ulcer. Some of those of which we have less certain knowledge are the following: The Staphylococcus pyogenes, when conditions are favorable, most frequently attacks the cornea. In spite of the fact that it often

inhabits the normal conjunctiva without causing any particular disturbance, it requires but a slight traumatism or denudation of the epithelium to give it an entrance to the tissues. The phlyctenula is a common manifestation of staphylococcic infection. The staphylococcic ulcer is usually circular, unless there is a definite area of traumatism, when it will take the form of the latter. Postoperative infection due to this organism is more amenable to treatment than that due to other species of cocci, as the pneumococci and the streptococci. The streptococcus may be the cause of corneal ulcers, usually of a most virulent and destructive type, and, by gaining entrance directly or metastatically to the interior of the eye, may cause panophthalmitis. The gonococcus when it attacks the cornea gives rise to a more or less typical ulcer which may appear at any time after the first thirty-six hours. It begins as a grayish, roughened area, makes very rapid progress and is extremely destructive. It is practically always secondary to the conjunctival infection, and is soon joined by staphylococci and other organisms, when it becomes an infection of the mixed type. The Koch-Weeks bacillus very rarely attacks the cornea, and when it does, usually selects adults. It is secondary to the conjunctivitis, the latter being generally of a severe type. It usually develops at the end of the first week of the conjunctivitis and continues to increase in size after the subsidence of the inflammation. The first indication of its presence is the appearance of an area of infiltration which later becomes necrotic, the slough separating and leaving a shallow ulcer with a gray base and sloping edges. The diplobacillus, it is claimed by many observers, frequently attacks the cornea, more often in localities where the organism is relatively common. There are no distinguishing characteristics; the ulcer may be marginal or central, shallow or deep. It displays a tendency to increase in size, and is often accompanied by iritis and hypopyon. In many cases it displays the characteristics of the serpiginous ulcer.

The diphtheria bacillus is particularly prone to attack the cornea. It is usually secondary to diphtheritic conjunctivitis, and it is conceded that it is the toxin of the organism that reduces the vitality of the cornea, thus favoring ulceration. It is generally found associated with the streptococcus or staphylococcus. The ulceration is characterized by a preliminary haziness of the co

nea, which has a blanched appearance; after a few hours this in turn is followed by a roughness and a final separation of the slough. The tubercle bacillus may be the cause of a tuberculous process, either by extension from the sclera or by a primary growth from the posterior layers of that structure. The former gives rise to rough infiltrated areas over the sclera and part of the cornea, this surface being studded by small tubercles. It is extremely difficult to detect the tubercle bacillus in the diseased tissues; they are best found by inoculation of the anterior chamber of a rabbit's eye with an emulsion of the diseased tissues. Primary forms have been described in which the infection is found on the posterior surface of the cornea. The entire surface may be studded with small gelatinous transparent nodes resembling fat droplets. These patients usually show an accompanying tuberculosis of the lungs.

Trachoma Bodies.—The morphology of these bodies, described by Greeff, Clausen, Frosch, Halberstaedter, and Prowazek is still obscure; therefore, pending further investigations, a definite description and classification cannot be given.

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